POWER PLANT ENGINEERING

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A Modern Substation

NEW 45TH STREET STRUCTURE OF UNITED ELECTRIC LIGHT & POWER CO. HOUSES EQUIPMENT SERVING DENSELY POPULATED DISTRICT; CONCENTRATION OF ELECTRICAL EQUIPMENT, 10 KW. PER CUBIC FOOT. BY ROY R. KIME

AS A GENERAL RULE, substations are located in out-of-the-way places, where few restrictions hamper their design. Of special interest, therefore, is the new 45th St. substation of the United Electric Light & Power Co., New York City, because of the unusual conditions which had to be met in its construction and arrangement. This substation serves the area between 27th and 82nd Sts., and the Hudson and East Rivers, a district thoroughly built up and inhabited by hundreds of thousands of people. In order to place it near the center of load, it was necessary to select a site among residences where real estate values are very high, and where quiet operation and freedom from vibration are essential.

On approaching the station, one is immediately struck by two peculiarities, both of which are due to the exigencies of its situation. One, as shown in Fig. 1, is the narrowness of the structure, and the other the space that has been left between each side wall and the adjoining

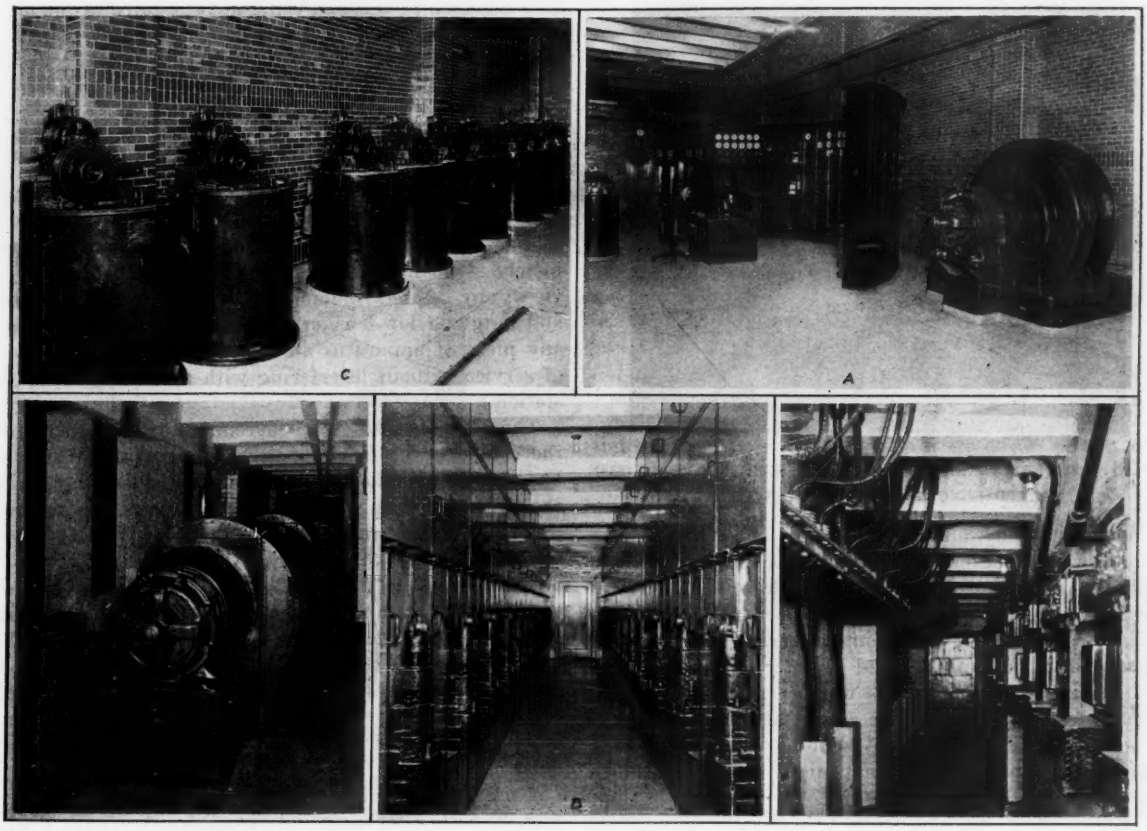


FIG. 4. INTERIOR VIEWS OF 45TH ST. SUBSTATION (A) GENERAL VIEW OF MAIN FLOOR (B) OIL CIRCUIT BREAKER AISLE (C) 85 KV.A. AIR CONTROL AUTOMATIC VOLTAGE INDUCTION REGULATORS (D) COMPARTMENT BELOW INDUCTION REGULATORS (E) VENTILATING BLOWERS (F) SWITCHBOARD AND CONTROL DESK

building. The building is narrow because it is confined to a plot intended for a single moderate-sized dwelling. The dimensions of the floor plan are 24 by 100 ft., which is a very cramped space for a building that will ultimately contain 12,500 kv.a. of electrical apparatus. Yet, as can be seen from the illustrations of the interior, though conspicuously constricted, it is in no sense crowded. Careful designing and the utilization of every single cubic inch of space were, however, required to obtain this result. Floors and walls consist in reality mainly of cables, conduits and pull boxes; and some of the apparatus installed had to be specially designed in order to take up a minimum amount of room. The capacity is 10 kw. per cubic foot, which is about double the usual concentration.

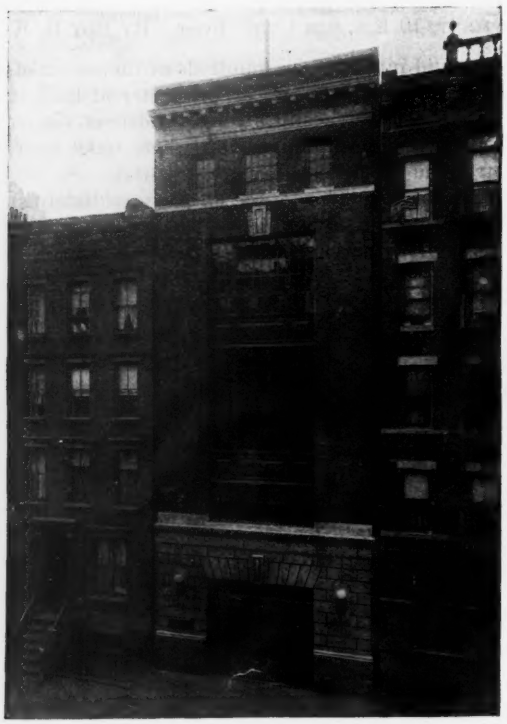


FIG. 1. EXTERIOR VIEW OF 45TH ST. SUBSTATION OF THE UNITED ELECTRIC LIGHT & POWER CO.

Space between walls of the station and the adjoining houses is one of several precautions that have been taken to avoid disturbing the neighbors with noise and vibration. It was decided that an air space would be preferable to the use of deadening material, to retain the noise within the building; and in order to guard against contact at any point, aprons were carried along as the brick work progressed, which established the proper distance between the walls and kept out pieces of brick, mortar and other material that might have fallen down the openings.

Every effort was also made to eliminate noise at its source. All rotating apparatus was arranged to operate as quietly as possible, and in addition, sound insulators, consisting of alternate layers of cork and sheet iron, were placed under the transformers, induction regulators and synchronous condenser. The condenser, being the machine most likely to cause disturbances, was mounted on a foundation that extends to bed rock, and is in no way connected with the rest of the building, thus preventing the vibrations of this machine from being transmitted to and magnified by the steel frame work.

Layout of the Station

THE BUILDING, which is 46 ft. high above the sidewalk, has three floors and a basement. On the main floor are the switchboard and its operation desk, the main transformers, the induction feeder regulators, a synchronous condenser, and a motor-generator set. On the two upper floors are the oil circuit breakers, with their accessories and the busbars. In the basement are vaults containing the connections for the apparatus on the main floor, the motor-driven blowers for ventilating the transformers and regulators and an air washer.

At present the station has three 7500-v. incoming feeders and ten 3000-v. outgoing feeders, but is designed for an ultimate capacity of five incoming and twenty outgoing feeders. Arrangements have also been made to raise the incoming voltage to 15,000 in the future, and all high-tension apparatus is insulated for this higher voltage, and all the transformers are provided with taps, so that the change-over can be made with little trouble and with no additions to the present equipment.

The load is mainly residence and theatrical lighting, the maximum power load being but one-third of the maximum lighting load. The power load is nearly constant throughout the day, while the lighting peak occurs at the close of the business day in winter and an hour or two later in summer.

Operating Arrangements

CONTINUITY OF OPERATION under all imaginable conditions is the ideal on which the plan of the station was based. Each piece of apparatus is safeguarded as completely as possible; spares are provided for all vital devices; any desired combination of incoming high-tension and outgoing low-tension circuits can be obtained; and any piece of apparatus and any circuit can be cut out of service without interfering with the operation of the station.

Three-phase, 62.5-cycle current, is transmitted from the company's 201st St. power house to the Waterside bus, from which tie feeders about 1.5 miles long run to the 45th St. station. These feeders terminate in separate manholes outside the station so that the burning out of one will not affect the others.

The feeders, in the form of 350,000 cir. mil. lead-covered cables, enter the basement of the station through tile ducts and run up the west wall in separate fiber conduits to pull boxes in the wall of the second floor, where the lead sheathes end in pot-heads. From each pot-head a cambric and braided cable runs to a 600-amp. oil circuit-breaker with disconnecting switches on both sides.

Each line now divides into two branches, as shown in Fig. 3, with a 600-amp. oil circuit-breaker with disconnecting switches in each branch. One branch runs to the high-tension side of a main transformer and the other to a common high-tension bus. Ordinarily each line from feeder to transformer is kept independent, but by means of the bus, any or all of the transformers can be supplied from the other feeders should one feeder be cut out;

while, on the other hand, should any transformer be cut out, the other two can be supplied from all three feeders.

From the secondary of each transformer a line provided with a 1200-amp. circuit-breaker runs to each of two bus-bars, called No. 1 and No. 2, respectively. From each bus a line runs to each outgoing feeder, the difference between these last two lines being that in the line from bus No. 1 there is an induction regulator, with a circuit-breaker on each side, while in the line from bus No. 2 there is a circuit-breaker only. Thus each feeder can be supplied either through a regulator or from a low-

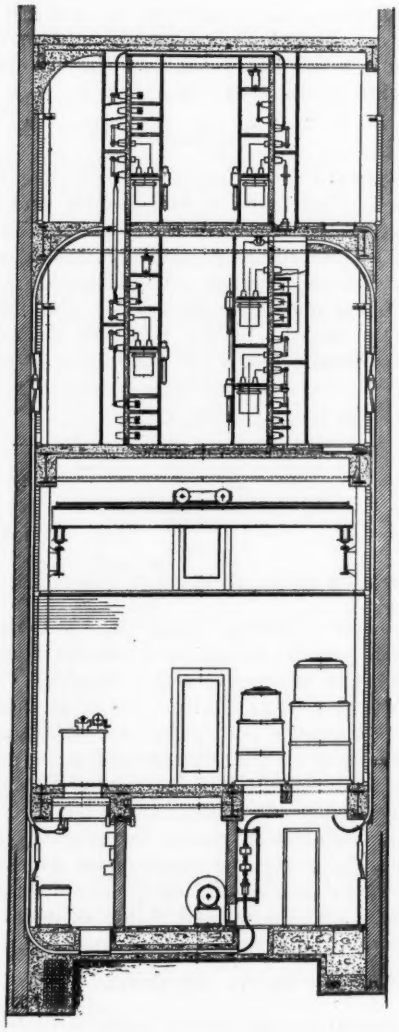


FIG. 2. CROSS SECTION OF 45TH ST. SUBSTATION

tension bus direct. A tie with a regulator connects the two buses, and provides means for regulating any feeder while repairs are being made to the regulator or circuit-breaker in the line from bus No. 1 to that feeder.

Both low-tension buses can be divided into sections, each connected with a transformer and with several outgoing feeders, so that any group consisting of a transformer and its outgoing feeders can be operated independently of the rest, or can be cut out if desired. The foregoing arrangement provides a very high degree of flexibility and permits the various elements to be grouped into a large number of different combinations.

Circuit Breakers

Bus-bars, circuit-breakers and their accessories are mounted in concrete compartments and are protected by light asbestos-board covers, mounted in steel frames. Barriers between circuit breakers are 3.5 in. thick, and those between the disconnecting switches are 2 in. thick.

A special base has been provided which carries all the circuit breaker parts, and all closing levers are connected to a single shaft. When the circuit breaker is in place, the only part that shows is the cast-iron casting of the operating mechanism, all live and moving parts being concealed behind covers.

Transformers

There are at present three banks of T-connected air-blast transformers, but two more will be added when needed. Each bank consists of a 2000-kv. a. unit for

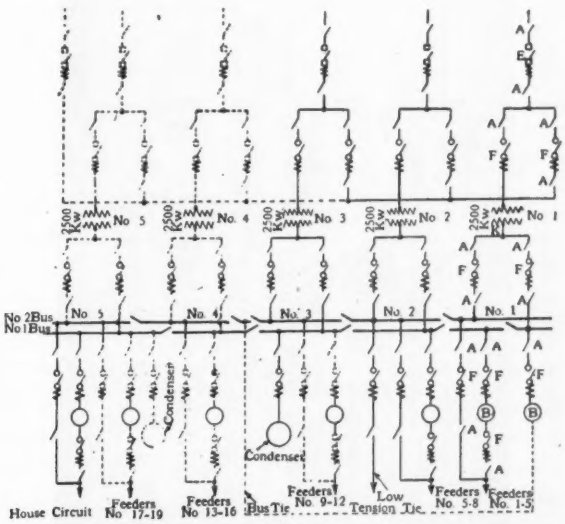


FIG. 3. SCHEMATIC DIAGRAM OF BUS TIES AND FEEDERS

lighting purposes and a 500-kv.a. teaser for power, connected as shown in Fig. 6. The primary winding of the teaser transformer is wound for 86.6 per cent of the voltage of the main transformer, giving a standard three-phase T-connection. The teaser secondary is wound for 70.7 per cent of the main transformer secondary voltage, giving 2100-v. between phases and 3000-v. between the two outside wires. The power load is supplied at 2100-v. in the usual manner. The lighting load is obtained from the two outside wires at 3000-v., and is transformed through the main unit practically as a straight single-phase load. The connections between the transformer units are such that the teaser is in service only when two-phase power is being used. Two transformer banks are at present sufficient to handle the full load, so that the third is a spare.

All wiring enters the transformers from vaults in the basement below, an arrangement making all connections easily accessible and adding greatly to the appearance of the main floor. Each transformer bank has its own ventilating blower, which starts automatically when the

transformer is energized; but if any one of the blowers is out of service, air can be supplied to its transformer from the other blowers.

Eleven 85-kv. a. air-cooled induction regulators are at present in operation, 10 controlling outgoing feeders and one for use in the tie between the two low-tension buses; 10 more can be installed to meet future requirements. These regulators have a range of 10 per cent above and 10 per cent below normal voltage. Line-drop compensators are installed in connection with the regulators, which provide for a normal voltage of 2750-v. across the outside lines of each feeder at the center of distribution. In order to conserve space, the operating mechanism on the top of the regulators has been so arranged that none of it projects beyond the case.

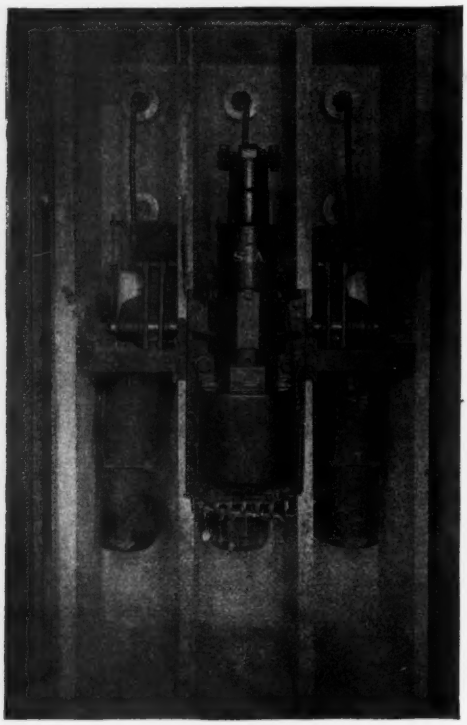


FIG. 5. TYPE OF CIRCUIT BREAKER USED AT 45TH ST. SUBSTATION

All the leads to the regulators run up from a compartment in the basement below. The regulator relays and the compensators are also mounted here. A large ventilating blower forces air into this compartment from whence it passes out through the regulators.

SYNCHRONOUS CONDENSER

TO ASSIST in correcting the power-factor and in stabilizing the voltage of the system, a 1000 kv. a. synchronous condenser is connected to low-tension bus No. 1. A second condenser will be added when the contemplated additions to the station are made. The condenser is provided with a special regulator, which has two elements; a voltage element, which responds quickly to voltage changes and prevents rapid variations of the bus voltage; and a current element, which operates to maintain an approximately constant current in the condenser, bringing the current very slowly back to normal, with changes in voltage. The object of this combination is to correct quickly for sudden changes of voltage and to allow sufficient time for the feeder regulators to readjust themselves to any new voltage on the bus.

The condenser has a direct connected 27.5-kw., 220-v. exciter, which also acts as a starting motor. Direct current for starting (and for other purposes, such as operating relays, switches, etc.) is supplied by a similar direct current generator operated by an alternating current motor. The exciter has twice the necessary capacity to serve the condenser, so that when the second condenser is installed there will be available three direct current machines, any two of which will be sufficient to excite the condensers and supply current for all other purposes, leaving the third as a spare.

SWITCHBOARD

ALL APPARATUS in the station is controlled from the switchboard. This board is semi-circular, and the control desk is located at the center of the circle formed by the board, so that all the points on the board are equidistant from the operator. All instruments, control switches, relays and other devices are mounted on the front of the board. In the rear are terminals and switches for testing relays and instruments. Leads are

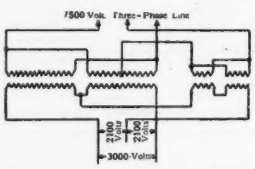


FIG. 6. DIAGRAM OF CONNECTIONS OF TRANSFORMER BANKS

carried from every voltage transformer in the station to a small panel on the control desk, so that readings can be taken on any instrument with a standard volt-meter.

Each circuit breaker control circuit is fused separately, and all control and instrument wires are carried through the floor to the basement and connected to the control cables through terminal blocks so that every wire is easily accessible. Beginning at the left in Fig. 4 can be seen the high-tension panels, the graphic meters, the voltage regulator for the synchronous condenser, the outgoing feeder panels with meters, circuit breaker control switches and relays, and at the extreme right the house circuit panel.

RELAYS AND METERS

EACH INCOMING high-tension feeder is protected by a reverse-power relay and an overload relay, which causes the circuit breaker to open under overloads of definite duration. Relays are also used to cut out the transformers in case of internal trouble, and also to protect the outgoing feeders. Each outgoing feeder is provided with a polyphase indicating wattmeter, the energy being metered on the secondary side of the transformers.

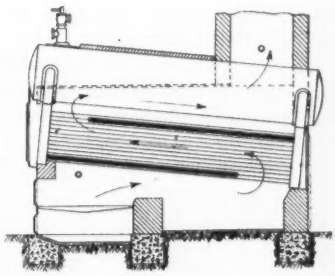
STATISTICS compiled recently by the United States Shipping Board, show that the Board now has 151 steamships, representing 950,000 deadweight tonnage engaged in carrying food supplies to the starving lands of Europe.

FUEL CONSERVATION LETTERS

By Joseph Harrington, Formerly Administrative Engineer for the State of Illinois

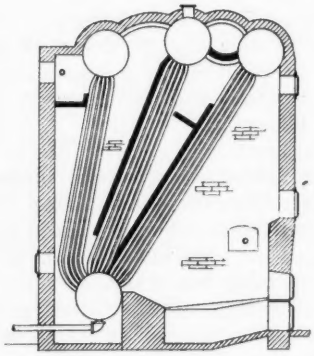
Boiler Baffles. Letter No. 9

A BOILER baffle is a partition placed among the tubes of a boiler to direct the flow of furnace gases in contact with the heating surface of the boiler. These may be longitudinal, causing the gases to travel lengthwise of the tubes, or transverse, causing the gases to travel at right angles to the tubes.

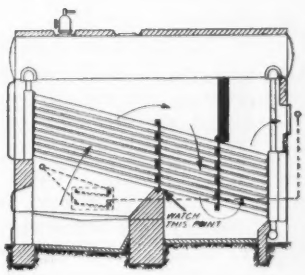


There have been many combinations and variations of these two principal divisions, but usually they have not proven successful and are difficult to maintain.

A boiler baffle wherein there is a considerable difference of draft pressure on the two sides, is undesirable, because this means increased leakage; and a leaky baffle is an expensive and undesirable affair. Inasmuch as the baffling of a boiler is for the purpose of increasing the length of gas travel and contact with the heating surface, there are portions wherein the gases are forced to travel in an unnatural direction. There also is the ever-present tendency to short circuit through leaks around the tubes. Obviously, therefore, baffles must be tight. Gas which by-passes the heating surface does no more good than water that by-passes the water wheel. Unfortunately for our convenience, baffles are placed in an inaccessible location, difficult to see, and even more difficult to repair. It is, however, a case in which a "stitch in time saves nine;" and your engineer's requisitions for baffle repairs should be honored at once.



To engineers, let me advise that you should have a differential draft gage attached to your boiler at all times with one connection to the furnace and another to the space just inside of the damper. Watch your draft gage until you are thoroughly familiar with the proper loss, and check this against the CO_2 as shown both at the end of the flame and at the damper. Determine what both of these should be at various rates of combustion and set them up as standards to be thereafter used as a gage. Not less than once a week you should make a specific draft loss test and record it on your log. Note, of course, the gas analysis and the rate of combustion at the same time. If there is an increased draft loss, look out for soot accumulation. If there is a decreased draft loss, look out for leaks in your baffles. Check this by your recording flue gas temperature thermometer. A leaky baffle means a higher temperature with lower draft loss; while heavy soot accumulation means a higher temperature with higher draft loss. I would suggest that every time the boiler comes off for cleaning or repairs, you have a special baffle inspection made and the result also recorded in your log book. Put a man on top of the tubes and another below; one holding a light and the other making observations. Let them inspect thoroughly every inch of baffle surface, and if leaks have developed plug them at once. Especially is this true if you have removed tubes at any time, or if you notice any tubes warping, or any special side-wall settlement. Particularly look out for the space between the bottom of the first flame plate and the top of the bridge wall in vertically baffled boilers. A loss here is most serious. Keep your baffles tight.



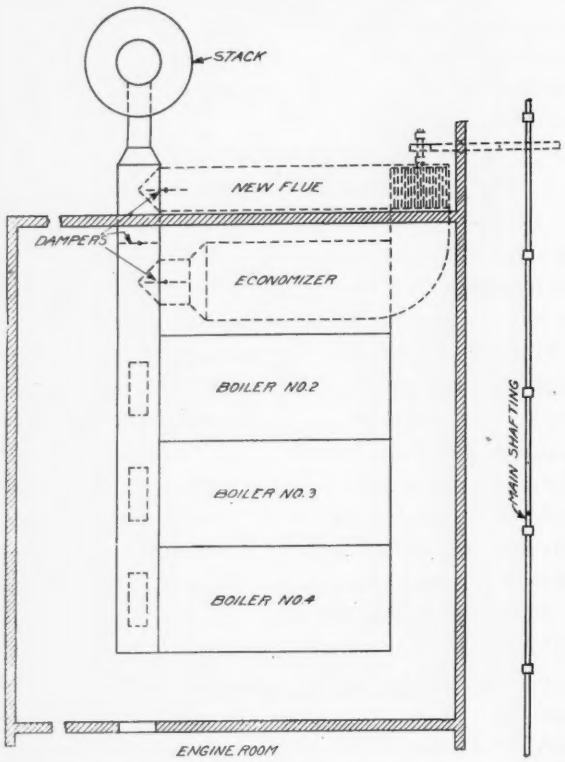
Economizers

Small Plant Installation Gives Good Results but Cost Was Excessive. By Tom Thumb

SOME years ago in a small factory was installed a fuel economizer. It is hardly necessary to say that the object was to get more steam from the same amount of fuel.

The theory of putting in new machinery to *save* fuel is perfectly correct, but the small plant owner hardly ever installs new machinery until the plant is overloaded and lagging, and then he installs apparatus to keep the wheels turning.

In the plant in question were installed three 6-ft. horizontal tubular boilers, with space left for a fourth, as indicated in the sketch. The uptakes were from the



PLAN OF ECONOMIZER INSTALLATION

front ends and the flue was in a perfectly straight line to the chimney.

At the time the plant was installed it was considered up to date in all ways and plenty large enough for any emergency; but the day came when the process was changed and the steaming capacity was hardly sufficient. Incidentally with that day came drummers or salesmen of all kinds. There were heater salesmen—but the plant owned a good heater. There were salesmen who sold smoke consumers, but really the plant did not make much smoke. There were salesmen who sold soda ash and kerosene under the name of some hifalutin' compound company—but the tubes and shells were free from scale. There was one salesman who tried to sell a new engine, but the present incumbent was a four-valve machine of no mean ability. Then came the boiler salesman. There were three of his boilers in the plant already, with room for a fourth. Then why argue the point, when the three were working the limit and yet the steaming capacity was too low? It looked as if up to date he had the best of the argument, when who appears on the scene but the economizer salesman.

Nobody in the plant, from the manager down to the night watchman, had ever heard of such an appliance.

He insisted that a saving of probably 25 per cent would obtain, and the plant would carry its load on the same amount of fuel that was now being consumed. Then, again, he explained the boiler feeds and the heating system vacuum pumps were in the space originally intended for number one boiler and would have to be moved, which would mean trouble and expense; but his apparatus would be installed above these pumps, without disturbing them in any way. The expense, he believed, would not be much, if any, higher than the cost of a boiler.

He called the boiler man one side and had a talk with him, and the boiler man rather reluctantly assented that the economizer was a most wonderful and scientific machine and would probably effect a good saving.

So it came to pass that an economizer was ordered for a specified sum that would serve 500 boiler hp. But the salesman neglected to state that all flue work and structural work must be paid for as a separate consideration; in fact, his company had nothing to do with this work but furnish blueprints.

After the structural work was in place, the economizer erector, with the assistance of several lumpers, installed the economizer. Then the metal workers from the boiler man's shop put the breeching or flue in place and the steam fitters had not been idle; thus the pipes were connected and everything was ready for a tryout.

The vents on top of discharge manifold were opened, so no pocket of air would be entrapped, and the blowoffs were opened frequently at the bottom on inlet and connecting manifolds to insure clean water.

I have neglected to mention a very important thing that was done a day or two before the breeching was completed. The scraping mechanism was set in motion to be sure that the cleaning process was limber and properly adjusted. This was a wise maneuver, as one of the clutches was found imperfect and a new one had to be obtained from the factory.

The day came at last when water was to be sent into the boilers through the economizer. The manager was there to explain to the owners why the expense of installation was so far in excess of the figures first submitted by the economizer salesman. The economizer erector was there to tell just how to manipulate the system for best results, and, of course, the chief engineer was there to get all the facts possible.

Now at this time let me state that the salesman had been so enthusiastic to get this economizer in the plant that he had not asked one question about the temperature they were obtaining, nor had he made any observa-

tions as to draft conditions, but the erector had observed these items and also a few more. Where the draft had been very good and the rate of combustion very brisk, a different condition prevailed now. The draft was decidedly less violent, and, incidentally, the flue gas was that much lower in temperature and steam would not hold.

The main flue damper was opened a little to get more draft and steam was again raised, but the feed from the economizer dropped about 15 or 20 deg. and, of course, that was a dead loss.

It looked bad for the showing of the outfit, to say the least, and the manager was almost frantic.

At this stage of the game the erecting engineer remarked that they would have to install an injector, since it was absolutely out of the question to pump cold water through the economizer when the engine was stopped, as this would cause dew to form on the tubes, which would form mud of the soot and stick the scrapers; also it would form corrosion on the tubes and bottom headers galore, with perhaps a bit on the top headers.

Do you blame the owners and manager for nearly losing their reason? A fan man was sent for, and he gave a figure on a fan to be run by a belt from the main shaft which came in just the right place.

But the manager had learned a lesson—he insisted on a price installed. This figure nearly caused suffocation; but it had to be fan or no draft, so, of course, the fan was ordered.

After considerable delay the fan arrived and was installed, and to give the outfit its due credit, things did work fine. The water went into the boilers at about 280 deg. F., which was considered a pretty good temperature; but it had gone in at 210 deg. F. before, so the difference was only 70 deg., which represented only a saving of slightly over 6 per cent. After you have been promised 25 per cent and only get 6, and the investment runs into several hundreds or even thousands of dollars, it hurts!

An expert was sent from the economizer works to see the installation. The first thing he ordered was the slowing down of the fan.

"Your settings are leaking and you are drawing in enough air to cool a refrigerator," he told them. "If there is a place to use exhaust steam don't put it all through the heater, but use it.

"We want the water only 100 deg., and we will raise it more in proportion from a lower degree than from a higher."

"What about the 25 per cent saving?" he was asked.

"We cannot guarantee a 25 per cent saving in any plant, unless it is possible to raise the temperature 25 times 11 deg., which would be practically impossible. The young man that sold you this outfit never saw an economizer in operation and was with us only a few weeks. Our company never could or would guarantee a saving of over 10 per cent at the most in a plant of this kind, employing horizontal return tubular boilers, at a maximum pressure of only 115 lb. gage."

This plant worked very successfully for some years, and then when it became necessary to get more steam, a turbo blower was introduced on each unit.

Strange as it may seem, the plant was now doing 25 per cent more work than at our first introduction, and was burning no more fuel.

So the economizer, induced draft and forced draft, all combined, did save what the economizer salesman promised, but the expense of installation, maintenance costs and interest on investment was more than the average small plant can afford.

Meeting the Boss

(A Part of Reconstruction)

By C. H. Stephen

DID you ever try to approach the boss
In the way a real man should?
When you guess his gains, do you figure his loss?
As you might, if you only would?
Have you thought, as you envied him his "snap,"
Of the lots of hard spots in Dame Fortune's lap?

Can you always say at the end of the day,
You have taken a real man's stand,
And worked just as hard when the boss was away
As you do when he's close at hand?
Have you ever found, when you get in a pinch,
That being the boss ain't so much of a cinch?

Have you ever figured that most of the men
Who are now in authority
Need not look far back to the working day,
When they labored like you and me?
Have you ever thought that 'most every man's use
Can be based on the product that he can produce?

Have you ever found, when you carry a chip
On your shoulders the whole day long,
You tire much quicker with snarls on your lip
Than when your heart carries a song?
Have you yet discovered that friction of toil
Disappears when you use human kindness for oil?

Did you ever try to face squarely the fact,
With justice and truth in view,
That if you are square in thought, deed and act,
The world will be square with you?
Dame nature taught mankind, long years ago,
That the harvest increases the foul seed we sow.

Have you ever thought that life's but a chance
To show of what stuff you're made;
That every clean thought helps your value enhance
And adds to the part you have played?
Have you ever thought that the things you impart
Reveal to the world the true state of your heart?

Have you ever thought that most of the wrongs
That you to the boss ascribe
Would vanish if only your heart held more songs
And your mind fewer diatribes?
If you banish envy, and think what is good,
You can then meet the boss as a real man should.

Fuel Oil and Its Application

By Mark Meredith

APART from its superiority to coal for marine propulsion, the use of oil on railways is advantageous in countries which are not favorably situated in respect to coal supply. A typical instance is that of the Mexican Railway where conversion from coal to oil has resulted in reductions of 32 per cent in the weight of fuel consumed per train kilometer and of 40 per cent of the cost of fuel. Oil can be handled from tank cars to storage tanks, and thence to locomotives with a much lower cost than the average cost of handling coal. Wastage in handling between shipment and consumption is eliminated. No men are required to load the engine, clean out ashpans, empty ashpits, load and haul away ashes.

In the comparative tests carried out by the Tehuantepec National Railway, the following information was obtained:

Gross weight of train, approximate, 500 tons; time getting 180-lb. steam from coal, 150 min.; time getting 180-lb. steam from oil, 70 min.; improved speed with oil over coal (average), 16.2 per cent; improved evaporation per lb. fuel, 5.62 lb. or 90 per cent; pounds of coal per 100 ton miles, 20.8; pounds of oil per 100 ton miles, 10.3.

By substituting oil for coal the output of boilers could be augmented by 30 to 100 per cent. Where used as an auxiliary equipment to coal-fired boilers to meet recurring peak loads, its use not only enables the plant to meet sudden and heavy demands, as in the case of electrical power stations, but may obviate the necessity of putting down additional boilers with the growth of the average output of current.

London Fog

Smokeless combustion of oil fuel would prevent or abate the smoke nuisance in closely populated districts. The Public Health Act of 1871 made it an offense to emit black smoke from factory chimneys, and in many instances the local authorities insist on its provisions being carried out. Much remains to be done, as is shown in the statement that in the administrative county of London, 76,000 tons of soot descend every year.

On a comparative test run at Wallsend Slipway on coal and oil on a Scotch marine multi-tubular type boiler, the following results were obtained:

Fuel Oil.—Specific gravity at 60 deg. F., 0.953; viscosity at 100 deg. F., 2.130 secs.; flash point, 160 deg. F.; calorific value in B.t.u., 18,430.

Water Evaporated.—Pounds of water per lb. of oil, 12.15; pounds of water per lb. of oil (from and at 212 deg. F.), 14.38; boiler efficiency, 73.37 per cent.

Coal.—Calorific value in B.t.u., 14,432.

Water Evaporated.—Pounds of water per lb. of coal, 7.76; pounds of water per lb. of coal (from and at 212 deg. F.), 9.31; boiler efficiency, 62.28 per cent.

Efficiencies as high as 84.5 per cent have been obtained on Scotch marine type boilers using Mexican fuel oil with the pressure system of oil burning.

At a large London factory Lancashire boilers have been converted and the following comparative figures obtained:

Calorific value—Fuel oil, 18,750 B.t.u.; coal, 11,451 B.t.u.

Evaporation per lb.—Fuel oil, 14.44 lb.; coal, 7.22 lb.

Evaporation per sq. ft. of heating surface—Fuel oil, 7 lb.; coal, 3.33 lb.

In the United States a large series of actual working temperature tests have shown that with coal the thermal efficiency of boilers varies from 66.6 to 68.1 per cent, with oil from 80.6 to 81.5 per cent.

In Great Britain fuel oil is used in industrial furnaces for such processes as billet heating, metal melting, riveting, bolt and nut making, and the manufacture of glass bottles. Of the three systems of burners for oil fuel, the pressure jet system (in which the atomizing agent is pump pressure and steam temperature) has been developed during the last 10 years to such an extent that it is now recognized as the most economical system for use under land and marine boilers and is being rapidly developed for locomotive purposes. Oil is drawn from the storage tanks by a steam pump through suction strainers, and delivered through heaters and discharge strainers to the oil fuel burners.

One point which usually appeals to every works manager is the fact that when utilizing oil the size of the furnace is reduced by 30 per cent; and the working area occupied by a furnace and its adjacent machines is only about 50 per cent of that of a coal-fired furnace, where piles of coal and ashes occupy a certain amount of space.

Burning Oil with Coal

Early in this century, a French engineer introduced the subject of oil as an auxiliary. The main advantage of auxiliary firing, lies in being able to obtain at will a large increase in the power of boilers. Combustion of the petroleum does not in any way prejudicially affect that of coal; in fact, by the introduction of jets of petroleum the condition and efficiency of combustion are improved by a more complete mixture of the gases. It is therefore not correct to consider the evaporative power of coal as identical when passing from ordinary auxiliary firing.

Admitting this as a principle, and supposing the quantity of water evaporated by the coal to be constant, the extra evaporation due to the better mixing of the gases is credited to the petroleum.

In several evaporative trials made on the same boiler of a French Navy ship, when coal alone was burned at the rate of 18.8 lb. per sq. ft. of grate area per hour the water evaporated per lb. was 9.05 lb. With a mixture of coal and 45 per cent oil, the corresponding figure was 11.34 lb. with a mixture of the coal and 64 per cent oil, 14.12 lb. In this last test the efficiency of the mixture was higher than when burning petroleum only.

These tests served as a basis for further experiment, about 4 yr. ago, by power station engineers. Their theory was that a poorer class of coal could be used in conjunction with oil fuel. When used alone the inferior coal tended to cake on the links of the chain grate stok-

ers, thereby retarding the necessary quantity of air from being drawn through the bars to complete combustion. The result was a smouldering mass, which traveled slowly along the bars and was dumped into the ashpit partly consumed. On analysis this ash would probably be found to contain high percentage of combustible matter. Therefore a much higher quantity of coal was burned per hour to maintain, say rated evaporation.

Theoretically this was due to the supposition that when fuel oil was applied the combustible gases rising from the coal fuel beds were quickly ignited, causing the top of this mass to become much more incandescent, and thereby tending to aerate the bottom mass, which would allow sufficient air to be drawn through to complete the combustion of the inferior coal.

Sufficient interest was taken in this theory for a large London power station to give sanction for tests to be carried out under a coal fired Stirling water tube boiler. One burner was introduced into each side of the boiler approximately one quarter way from the back of the grate, the burners being opposite each other. Oil was stored in an overhead tank capable of holding 3 or 4 days supply. It gravitated to the burners, which were of the Kermode steam jet type, operating with steam as an atomizing agent at a pressure of about 25 lb.

Nutty slack, having a calorific value of 10,400 B. t.u., was employed in one test, and a boiler efficiency of 69.25 per cent was obtained. The temperature of the combustion chamber was 2648 deg. F. and uptake 660 deg. F.

Concluding a series of experimental mixed burning tests, a mixture of nutty slack having a calorific value of 10,300 B. t.u. was employed with Mexican fuel oil having a calorific value of 18,750 B.t.u. A boiler efficiency of 74 per cent was obtained. Combustion chamber temperature was 2850 deg. F. and uptake 628 deg. F. On a B.t.u. basis the proportion of oil to coal was 8 per cent, and on a weight basis 4.96 per cent. Comparative costs showed a monetary saving of 6 per cent in using the mixture mentioned rather than coal alone.

With oil at a cost of 2½ times that of coal, and burning in the aforesaid percentages, the tests showed that a saving is effected which should induce power station engineers to consider adopting this method of firing in the super-power stations of the future.

Graphite

ITS USE AND ABUSE.

BY JOHN WALLACE

IT HAS remained for the present generation to extract the word graphite from the mire of ignorance and incredulity and to place the product on an understandable level where those engineers, not too prejudiced to learn, may grasp the import of its possibilities as a cylinder lubricant. Science in its researches has been instrumental in bringing to light a graphite, familiarly termed 99 per cent pure, the equal of which, under certain conditions and for certain purposes, has never been found. The processes of manufacture differ widely, but the electrical method is as positive as any in removing grit and all other foreign matter.

What prestige graphite ever possessed in the old days was slowly but surely dissipated when engineers, using graphite for the first time, later found their engine cylinders so badly scored from the graphite's gritty ingredients as to necessitate reboring them. No engineer in the country relishes such a procedure, and it is no wonder that, one and all, they returned to oil as a lubricant and condemned the graphite in loud and vivid terms. Feeling that their prejudice against graphite was righteously justified, under no circumstances could they again be induced to use it. They gave no thought to the fact that as times changed so did graphite, and thus they continued to surround their common sense with the barriers of prejudice. As a result, this form of lubricant, in its better states, stood no chance of recognition.

It is a well-known fact that superheat tends to break down the best grades of cylinder oil, thereby causing untold valve and cylinder troubles. Also, hard spots in the metal of steam rings, scarcely discernible to the eye, will wear away less quickly than the remainder of the rings, and eventually lead to a scored cylinder. With a new set of steam rings and the judicious use of graphite the necessity of reboring the cylinder is sometimes done away with. The manner in which this was, in one case, accomplished is illustrated by the experiences of a certain chief engineer, in charge of the steam plant of a large paper mill in New Hampshire.

At the outbreak of the World War the prime movers in this mill consisted of eight Corliss engines of varying sizes. The best grade of cylinder oil obtainable was used and fed, through sight feed lubricators, directly to the steam valves. Reasonable care with the valves and cylinders of all these engines, and the use of the best grade of oil, insured a minimum of trouble.

Just as the quality of nearly everything fell off when the United States started filling large foreign contracts, so the quality of the oil and the iron became steadily worse. Then it was that the chief's real troubles commenced. Repeated complaints to the purchasing department relative to the poor quality of these two items were unavailing. With United States' entry into the conflict, matters went from bad to worse. It soon became the alternative of using what he received or of shutting down the plant. He well knew that his employers would scarcely brook the latter expedient, so he clamped his jaws and mentally berated the abnormal market conditions.

Being of the old school, and having once had a serious set-to with gritty graphite, he never gave that means of lubrication a passing thought. Continued valve and cylinder trouble was his sorry lot. Increased steam consumption, due to leakage and friction, caused the already sadly depleted coal pile to shrink most fearfully and so brought the wrath of his superiors down upon his old shoulders. Before long the chief's health broke down under the burden of overwork and worry and he resigned.

A young man was employed to fill the shoes of the old engineer, and a mighty hard time he had of it for a while, but he was of the new school and harbored no prejudice against graphite. Therein lay possible immunity from the most of his cylinder and valve troubles, and he determined at least to give it a try.

After obtaining the sanction of his superiors, orders were placed for graphite and for pumps to handle a graphite and oil mixture. When they arrived he had

them installed, and led the discharge from the pumps into the side of the throttle valve where the atomizers thoroughly mixed the graphite and oil with the incoming steam.

After the pumps were in use two weeks he removed the cylinder heads from all the engines and inspected the cylinders. He found that although the walls in two of the cylinders were for the most part smooth and glossy, they were so cut before the graphite had been used that they necessarily had to be rebored. This he had done. The remaining six cylinders were without a flaw. Not a mark was revealed anywhere, and streaks a little darker than the cylinder metal proved how well the graphite had filled the former grooves. For the first two weeks the chief used 1¼ oz. of graphite to every gallon of oil, and after that period ¾ oz. to every gallon. He now uses a cheap stock cylinder oil in conjunction with the graphite, and without fear of contradiction, one could state that it simply carries the graphite to the engine, and, having accomplished this work, is useless as far as real lubrication goes. From that time on his cylinder and valve troubles lessened, his steam consumption dropped, his engines worked smoother, and by reason of decreased friction were capable of doing more and better work.

Later, upon comparing costs, he found that it required less of the mixture to insure thorough lubrication than it did of the oil alone, one gallon of the mixture going one-half again as far as one gallon of oil. One secret in the use of graphite is to make sure it is held in suspension. Most pumps on the market accomplish this automatically.

Many engineers are very set against the continuous use of graphite, but this engineer is using it at this date and is saving his employer's money by doing so. Better looking cylinders and valves have never been seen in the history of the mill's operation.

It might be well to mention that, to prevent any great amount of either oil or graphite from entering the boilers of his steam plant this engineer has installed a feed water filter and grease extractor, which effectively removes about all of it. His feed water being much cleaner and freer from oil, his boilers need less attention. This saving in labor has already paid for the filter.

So to those engineers of the old school and to those of the new who have never given the present-day graphite a fair trial, put aside your prejudices, your petty opinions and remember that in cylinder graphite you will find a lubricant that will positively stand up under superheat in any amount and that will work wonders in eliminating friction loss which, in any engine of the reciprocating class, makes for inefficiency and which must be overcome as far as conditions will permit.

BENJAMIN FRANKLIN gave this advice to a young man: "Keep an exact account for some time, both of your expenses and your income. If you take the pains at first to mention particulars, it will have this good effect: you will discover how wonderfully small trifling expenses mount up to large sums, and will discern what might have been and may for the future be saved without occasioning any great inconvenience."

Thrift Is Just Efficiency

BY JAMES H. COLLINS

THE average family income in Great Britain is $1080, or $236 per capita, yearly. Out of that income John Bull succeeded, during the war, in teaching two members of every British family to save and invest in war bonds and stamps $140 each, according to an article in Printers' Ink. That is, each family saved more than one-fifth its income.

A similar comparative saving by the hundred millions of people in the United States invested in Thrift Stamps and War Savings Stamps would add tremendously to the nation's available supply of capital, and would transform the United States from a nation of spenders to a nation of savers.

The results in Great Britain were accomplished by practical efficiency suggestions—how to save on gas, laundry bills, cooking, soap, coal, food, etc. A national organization known as the Salvage Club was formed, with branches everywhere, gathering up bones, paper, cans, tin foil, shoes, clothing and other things usually consigned to the ash can. This organization published a monthly newspaper called Salvage, printed on paper made from recovered waste materials. One week's bones from the average household was found to yield edible fat and also ingredients to make explosives for several shells. A quarter of a pound of waste paper made a charger case. Thousands of boy and girl scouts helped gather waste materials. Business concerns rooted out their old account books, letter files, and documents, selling them for waste paper. Scrap metal of all kinds was collected and sold, and one junk dealer adopted a receipt for scrap metal showing how much the person who saved and turned it in had contributed to help make war munitions.

Thrift is just efficiency, after all. It goes much farther than the saving of pennies or dollars. It is the saving of materials and time which run into money very quickly.

REPORT OF coal mining conditions shows the greater part of mines running at 50 to 80 per cent capacity during January. In the latter part of the month the production was less than consumption, many plants using coal accumulated last summer, and awaiting the removal of zone and price restrictions before placing further orders. Such restrictions have now been removed, and an increase in volume of orders may be expected.

With the mild winter and reduced demand for industrial purposes, all chance for a coal shortage has disappeared, and from now on the coal market will settle to normal pre-war conditions.

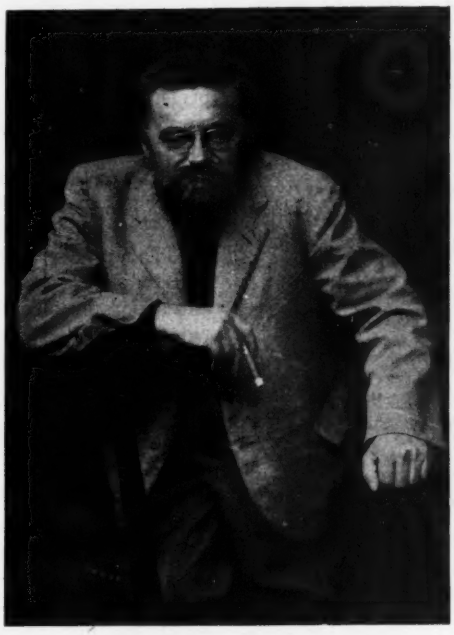
Restrictions on shipment and sale of anthracite have been removed with resulting increase in production, and though prices will probably not be lowered, no shortage in deliveries is to be anticipated. It is too early as yet to predict what next season's prices will be; but the anthracite industry has never yet shown a tendency to lower prices after they have once been raised, and it would seem unlikely that it will be done now, particularly in view of the decreasing reserve-in-ground of anthracite and the increasing demand.

CHARLES P. STEINMETZ

GENIUS OF ELECTRICAL ARTS, ACTIVE CITIZEN AND EXPONENT OF TECHNICAL EDUCATION. DRAFTING WAS HIS FIRST VOCATION, THEN PHENOMENAL RESEARCH AND DEVELOPMENT WORK RESULTED IN RAPID RISE. BY WALTER PAINTER

ENGINEER, educator, author and useful citizen is Dr. C. P. Steinmetz of Schenectady, N. Y. He is one of the most remarkable electrical engineers in the world. Only a trifle over four feet in height, he is one of the biggest men in America by the sheer power of his brain. Physically one of the most handicapped of men, his abnormal capacity for work and supreme skill with the magic forces of electricity have placed him paramount in the engineering profession.

Charles Proteus Steinmetz was born April 9, 1865, at Breslau, Germany. He was educated at the gymnasium (high school) and then the University of Breslau, where he studied mathematics and astronomy, then physics and chemistry, and finally took a short course in medicine and national economy. Involved in the social democratic agitation against the government, he escaped to Switzerland in 1888, and there studied mechanical engineering at the Polytechnische, Zurich.



Charles P. Steinmetz

In 1889 he came to America, virtually penniless, and found a position with the Osterheld & Eichemeyer Manufacturing Co., first as draftsman at $2 a day, then as electrical engineer and designer, and finally on research work in charge of the Eichemeyer laboratory.

With the absorption of the Eichemeyer interests by the General Electric Co., Dr. Steinmetz was attached to H. F. Parshall's calculating department in Lynn, Mass., and with the transfer of the company's headquarters to Schenectady in the spring of 1894, Dr. Steinmetz organized and took charge of the calculation and design of the company's apparatus, and of the research and development work. For a number of years Dr. Steinmetz was Professor of Electrical Engineering at Union University, and at the present time is Professor of Electro-physics at Union University, at the same time retaining his connection with the General Electric Co. as chief consulting engineer.

Although a smaller number of patents are credited to his name than to Edison and others, it was the scientific principles discovered by Dr. Steinmetz that made many inventions possible. His "Theory and Calculation of Alternating Current Phenomena," published in 1897, created a marked sensation in engineering circles and revealed a new field. As a valued contributor to engineering journals, his investigations and theories have proved highly instrumental in furthering electrical progress. Most of his papers and discussions have appeared in the Transactions of the A.I.E.E. Among the books published by Dr. Steinmetz are: a popular work on "Astronomy and Meteorology," "Radiation, Light and Illumination," "General Lectures on Electrical Engineering" and "Theoretical Elements of Electrical Engineering."

Personally he is one of the simplest, most straightforward of human beings, and unassuming. In disclaiming any particular credit for the advancement of electrical engineering or the successes of his company, he says he has merely done a part of the large work to which many have contributed.

Concerning success, he recently said he believed the fundamental principle of all human progress was the "divine discontent" which makes men strive for better conditions and improved methods; the dissatisfaction of Robert Fulton with sailing vessels which led to the steam boat, and that of Stephenson which resulted in the introduction of the railroad engine. Men who are hard to satisfy move forward, those who sit back comfortably, contented with their accomplishments, move backward.

He explained that by discontent he did not mean the variety which expresses itself merely by sour grumbling and bitter complaint or the desire for more money, but the brand of self-dissatisfaction which leads to thinking and to the fitting of one's self for a more skilled grade of work. Discontent alone, he said, will not make a man a superintendent, but will generate thoughts of his self-improvement, induce him to ask questions, to listen when skilled men talk, and to study more at shop and home.

"Today the chances for a man to secure a technical education are excellent," he said. "When I came to America education was at a low standard. There was

a strong prejudice against the educated men in many quarters, a trace of which still lingers here and there. For many years the educated man was supposed to be unfit for practical use, a visionary. But today the more thorough a young man's education, the more big corporations will welcome and encourage him."

In 1902 Dr. Steinmetz received the honorary Master of Arts degree from Harvard University, and in 1903 the honorary Ph.D. degree from Union University. He has lectured extensively before colleges and engineering organizations, and is a zealous worker in a score of scientific and civic societies.

Dr. Steinmetz is Past President of the National Association of Corporation Schools, Vice-President of International Association of Municipal Electricians, Honorary President of International Electrical Congress, is Past President of the A.I.E.E., Honorary Member of the N.E.L.A., Fellow of the A.A.A.S., Member of the (British) Institution of Electrical Engineers, Member of the American Mathematical Society, of Quaternion Society, the A.S.M.E., Electrochemical Society, Illuminating Engineering Society, Physical Society, American Philosophical Society. He is at present President of the Common Council and President of the Board of Education of the City of Schenectady, and is also chairman of the board of directors of the American League for National Unity.

Truly his is a most useful engineering career. He closely approaches what was recently termed "an unoccupied rung in the engineers' ladder of fame"—the more active participation in general public affairs and the acceptance of greater civic responsibilities.

Every Disabled Soldier and Sailor Should Know

THAT the government is resolved to do its best to restore him to health, strength and self-supporting activity.

That until his discharge from hospital care the medical and surgical treatment necessary to restore him to health and strength is under the jurisdiction of the Military or Naval authorities.

That the vocational training which may be afterwards necessary to restore his self-supporting activity is under the jurisdiction of the Federal Board for Vocational Education.

That if he needs an artificial limb or other orthopedic or mechanical appliance the Bureau of War-Risk Insurance supplies it free upon his discharge, and renews it when considered necessary.

That if, after his discharge, he again needs medical treatment on account of his disability the Bureau of War-Risk Insurance supplies it free.

That if his disability does prevent him from returning to employment without training, and he elects to follow a course of vocational training provided by the Federal Board, the course will be furnished free of cost, and he will also be paid as long as the training lasts a monthly compensation equal to the sum to which he is entitled under the War-Risk Insurance Act, or a sum equal to the pay of his last month of active service, whichever is the greater; but in no case will a single man or a man required by his course of instruction to live apart from his dependents receive less than $65 a month, exclusive of the sum paid dependents; nor will a man living with his dependents receive less than $75 per month, inclusive of the sum paid to dependents.

That if his disability does not prevent him from returning to employment without training, and he elects to follow a course of vocational training provided by the Federal Board, the course will be furnished free of cost to him, and the compensation provided by the War-Risk Insurance Act will be paid to him, but no allowance will be paid to his family.

That in addition to the above, the family or dependents of each disabled man will receive from the government during his period of training the same monthly allotment and allowance as that paid prior to his discharge from the Army or the Navy.

That upon completion of his course of training he will continue to receive the compensation prescribed by the War-Risk Insurance Act as long as his disability continues.

That if he fails to take advantage of these opportunities he will find himself badly handicapped when he is obliged to compete with the able-bodied men who come back to work after the war.

That the Federal Board, through its vocational experts, will study his particular disability and advise him as to the proper course to pursue and give him free training for the occupation best suited to him.

That on the satisfactory completion of his training the Federal Board, through its employment service, will assist him to secure a position.

That public authorities and other large employers will, in many cases at least, give the disabled soldiers and sailors preference when filling vacant positions, provided they possess the training necessary to fill them.

All disabled soldiers, whether in or out of the hospital, should address their communications either to the Federal Board for Vocational Education, Washington, D. C., or to the district office of the Federal Board of the district in which he is located.

THE U. S. BUREAU of Standards has made an exhaustive investigation of the subject of anti-freezing mixtures for cooling automobile cylinders, and its conclusion is that the most satisfactory material to use, which will not injure either the radiator, engine or the rubber connections, is alcohol mixed with the cooling water in sufficient quantity. For a temperature of 27 deg. F. a 10 per cent solution of alcohol is required; for 10 deg. F., 30 per cent; for —2 deg. F., 40 per cent, and for —18 deg. F., a 50 per cent solution. The best way to make up the proper strength mixture is to use a hydrometer, and the specific gravities are respectively 0.988, 0.968, 0.957 and 0.943. Of course the alcohol boils off quite rapidly, and the cooling medium must be tested and more alcohol added every few days, but it appears to be the only safe system. Glycerine is sometimes added to reduce the loss of alcohol, but in effective quantities it attacks the rubber connections seriously; and calcium chloride solutions, so often recommended, are decidedly corrosive, especially on the soldered joints of the radiator and on aluminum or alloys that are often used in manifolds, pumps, etc.

Atlas Stationary and Marine Steam Turbines

LATE DESIGN OF EUROPEAN STEAM TURBINE FOR MARINE SERVICE DEVELOPS 85 PER CENT AS MUCH POWER IN REVERSE AS IN FORWARD PORTION

RECENTLY the Atlas Engineering Co. of Copenhagen started building steam turbines, as shown in Engineering of London, for marine as well as stationary use. Figure 1 is the stationary type, the familiar pattern of the straightforward impulse turbine, with one velocity compound stage. This is likewise the form for the forward portion of the marine type, but the reverse portion of the marine type has two velocity compounded stages and is capable of developing 85 per cent of the full power of the forward portion.

Diaphragms are of cast iron, with guide blades of steel cast on. They are split along a horizontal line, a practice now universal, to facilitate repairs.

Steam supply to the first stage is taken through a nozzle box to which high temperatures and pressures are confined. The wheel blades are cut from solid steel of the pattern originally introduced by the British Westinghouse Co., in which the shrouding is in one piece with the blade. These blades are assembled in their groove through a "light," cut for the purpose, as indicated in Fig. 2, the stopper piece for which is shown in Fig. 3.

Arrangement of the valves, governor and oil pumps follows familiar lines. The governor valve, which is of the balanced double-beat type, is moved to suit the load by means of an oil operated servomotor, the valves of which are controlled by the governor. The usual overtaking gear is provided to prevent hunting. The emergency governor, at the left, Fig. 1, is of the sliding pin type, which trips the stop valve in case of a runaway. This stop valve, automatically closing under the action of a spring, can also be tripped by hand. It is common practice to use the hand operated trip gear for shutting down the turbine, which ensures that the emergency gear is maintained in working order.

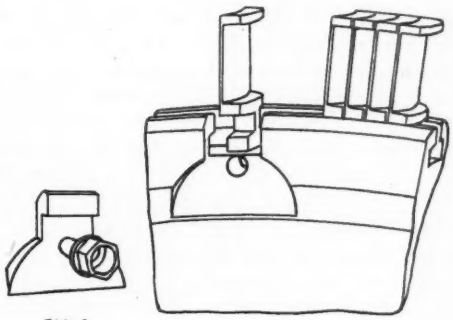


FIG. 2. "LIGHT" CUT FOR THE PURPOSE OF ASSEMBLING BLADES IN THEIR GROOVE
FIG. 3. STOPPER PIECE FOR "LIGHT" CUT

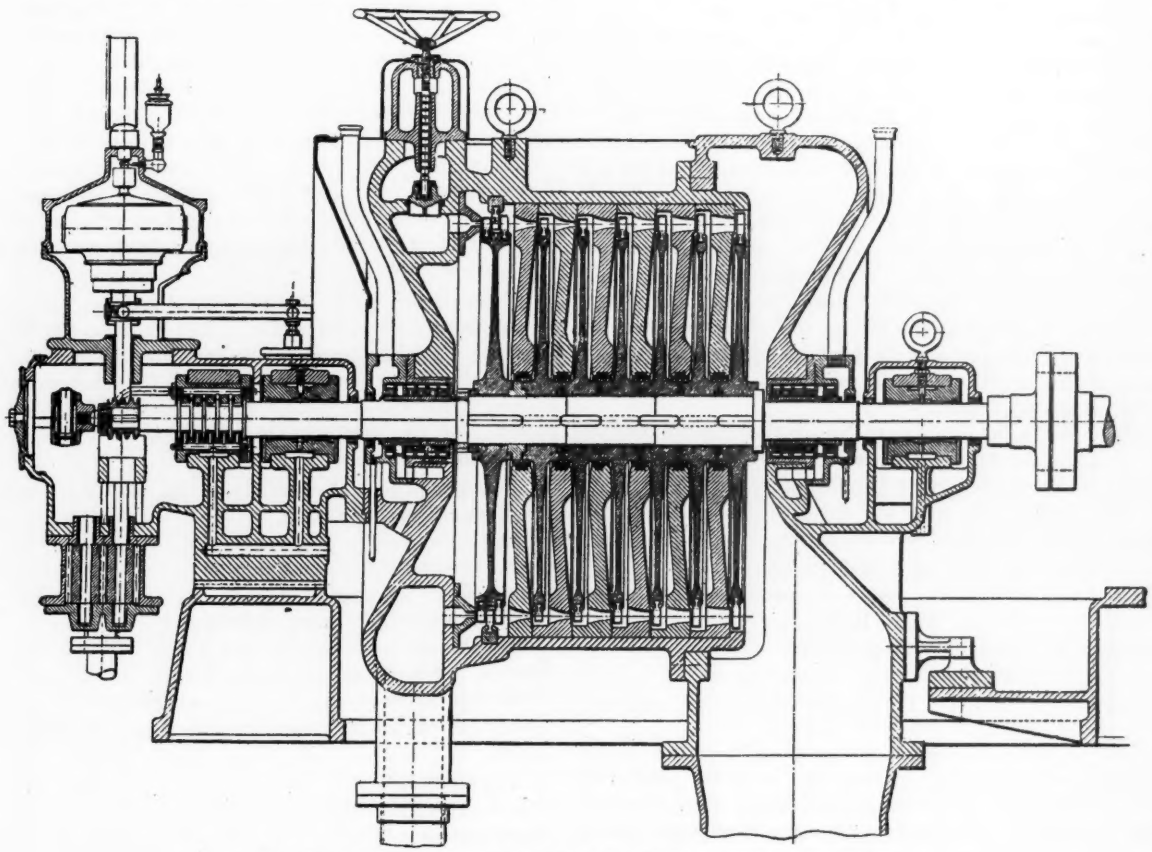


FIG. 1. SECTIONAL VIEW OF ATLAS STATIONARY STEAM TURBINE

Graphic Calculation of Boiler Efficiency

Development of a Chart Taking Into Account All Factors of Problem. By Ralph E. Turner

TO CALCULATE the combined efficiency of a boiler and furnace after a day's run is one of the most trying and complicated problems the operating engineer has to solve in his daily work. Factors are involved which necessitate reference to tables or charts, and when these values for the special conditions are all obtained they must be substituted in a rather lengthy equation. All this takes time and very careful calculation if any reliance is to be put in the result.

The graphic method of solving problems appeals to many engineers for the reason that it is rapid and, if the chart is properly designed, with reasonable care, the accuracy is as close as that of the instruments with which the data is taken. It has the further advantage that the problem is completely solved on the chart without reference to handbooks or data other than that taken from the daily log sheet of any modern power plant.

Starting with first principles, the per cent efficiency of a boiler is the ratio of heat output to heat input multiplied by 100. The heat output is the total amount of heat in the steam delivered over the period of the test minus the total amount of heat in the water fed to the boiler over the same period; this heat output is found by multiplying the pounds of steam delivered, or, assuming no loss through blowoff or safety valves, the pounds of water fed to the boiler, by 970.4 (the latent heat of steam at atmospheric pressure) times the factor of evaporation. The factor of evaporation is usually found from tables when saturated steam is used, but when superheat is given to the steam, the additional heat is calculated from the specific heat of superheated steam as given in tables or charts published in text-books or other standard works.

The heat input is obtained by multiplying the pounds of coal burned during the period of the test by the heat value of the coal in British thermal units per pound.

Developing this into the form of an equation, we have: Per cent combined efficiency =

$$\frac{F \times w \times 970.4 \times 100}{W \times \text{B.t.u.}}$$

in which F = factor of evaporation,
w = weight of water in pounds,
W = weight of coal in pounds,
B.t.u. = heat value of 1 lb. coal.

It is always desirable to know the pounds water evaporated per pound of coal, i.e., $w \div W$. For this reason the chart uses the combined factor, thus eliminating one section. In many plants the feed water meter reads in cubic feet rather than pounds; in these cases the lines representing cubic feet per pound of coal should be used instead of pounds water per pound coal, and then a correction must be made for the temperature at which the water is measured, as is done in section 4 of the chart.

To get the formula into better shape for the design of the chart, and to aid in the explanation, we will change the order a little, as follows:

$$\text{Efficiency} = \frac{F}{\text{B.t.u.}} \times 970.4 \times 100 \times \left(\frac{w}{W}\right)$$

Section 1 of the chart is in reality two charts, one superimposed on the other; one shows the relations of pressure, superheat and total heat; the other, the relations between total heat, feed water temperature and factor of evaporation. To find the factor of evaporation, enter the chart at the proper point on the scale designated as "Pressure lb. Gage," and pass horizontally to the left to the line representing the degrees of superheat contained in the steam; directly below this point will be found the total heat in the steam; from the above intersection pass vertically up or down to the line representing the average feed water temperature for the day, then horizontally to the left will be found the factor of evaporation.

The next step is to divide this by the B.t.u. of the coal, and multiply by 970.4×100, which is done in section 2 of the chart by merely passing to the left from the factor of evaporation to the line representing the heat value of the coal used, directly beneath the point of intersection is the desired product, which may be termed the boiler constant, as the factors entering this quantity are usually maintained constant in any given plant except for variation in heat value of coal.

From the point in the boiler constant scale thus obtained, pass vertically down to the line representing pounds of water evaporated per pound of coal, then horizontally to the left will be found the per cent combined efficiency.

If the meter reads in cubic feet instead of pounds, pass vertically down from the correct point in the boiler constant scale to the line representing the cubic feet water evaporated per pound of coal, then horizontally to the right will be found the efficiency in the scale plotted for the temperature of the feed water as it passes through the meter.

Two problems are worked out on the chart which show clearly how to use it.

Example A:
Steam pressure = 175 lb. gage.
Superheat = 150 deg.
Feed water temperature = 210 deg. F.
Heat value of coal = 12,500 B.t.u.
Pounds water per pound coal = 7.75.
Cubic feet water per pound coal = 0.1295.
Combined efficiency of boiler and furnace = 68.4 per cent.

Example B:
Steam pressure = 125.
Superheat = 0.
Feed water temperature = 200 deg.
Heat value of coal = 13,000 B.t.u.
Pounds water per pound coal = 6.5.
Cubic feet water per pound coal = 0.107.
Combined efficiency of boiler and furnace = 50.75 per cent.

In plants where the pressure, superheat, feed water temperature and heat value of the coal remain the same from day to day, the boiler constant will not change, so when this value is determined, it can be marked in the boiler constant scale.

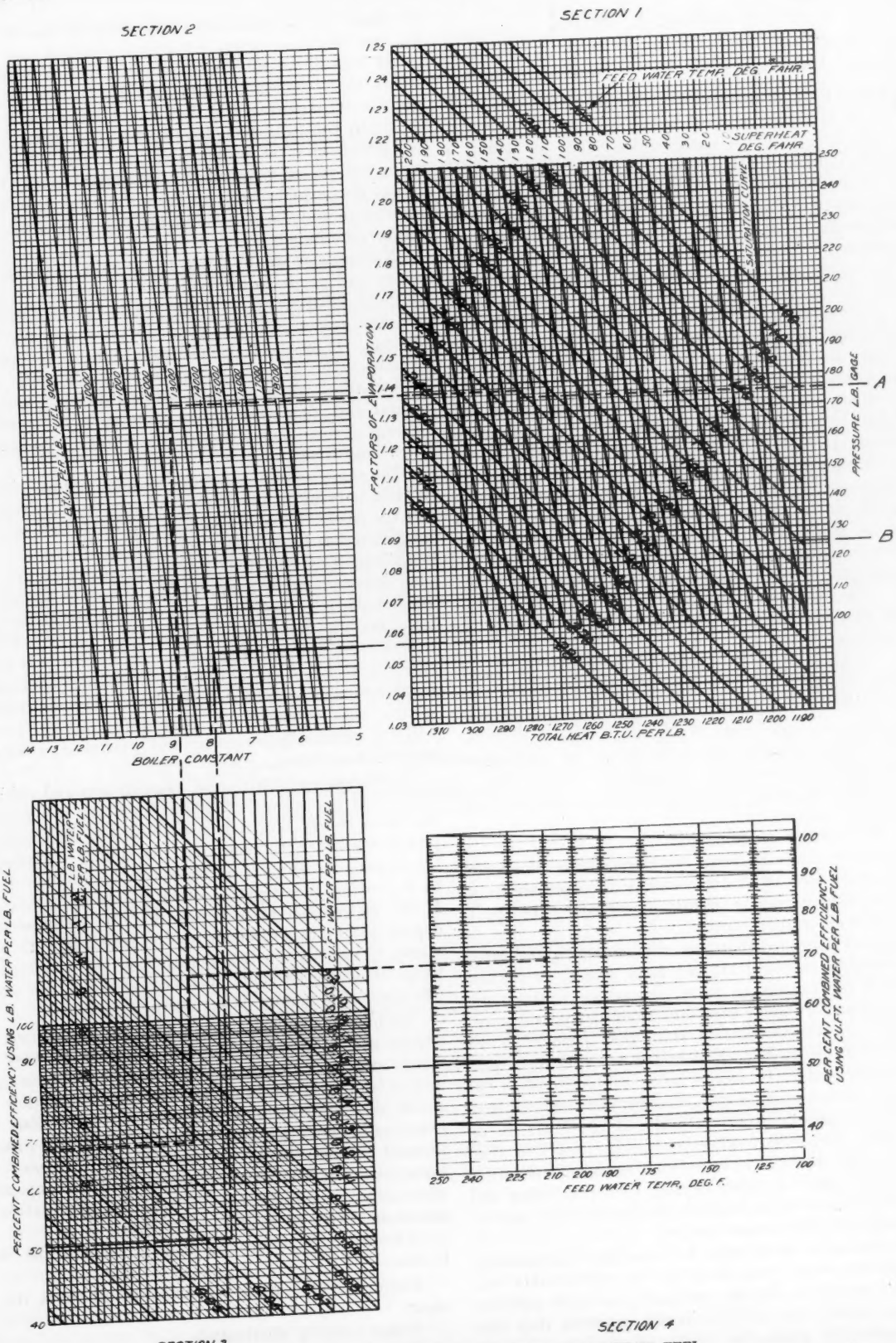


CHART FOR FINDING COMBINED FURNACE AND BOILER EFFICIENCY WHEN FEED WATER IS MEASURED IN CUBIC FEET OR POUNDS

Temperature Control

SAVING OF STEAM AND MATERIAL BY AUTOMATIC CONTROL IN INDUSTRIAL PROCESSES. BY G. B. BURKE

PROBABLY every factory manager in this country is fully conversant with the Federal Government program for fuel conservation, and, no doubt, a great deal has been accomplished. The problem is, however, to prevent as far as possible relaxation and the consequent slipping back to the proverbial American wastefulness because there always has been plenty of everything.

The very useful work done by the Fuel Administration in spreading broadcast the vital importance of fuel economy will not be lost by any means. It has already resulted in concerted effort by some cities to organize the power users, and under the direction of those familiar with the problems, such localities will undoubtedly save much fuel. In addition there will probably be a continuation of the Fuel Administration program under the direction of the U. S. Bureau of Mines, acting in conjunction with leading manufacturers of equipment. If there is a tendency to revert to wasteful methods, it will be in the face of a vigorous campaign to maintain the high standard desired by the Fuel Administration.

Quite apart from the question of plant and equipment design and maintenance, and the purchase of the proper grade of fuel, the effort to secure high fuel economy implies:

1. Intelligent operation of boiler furnaces to insure minimum waste.
2. That heat generated by the fuel be transmitted without unnecessary waste to produce steam.
3. Conducting live steam to points of application through properly insulated containers.
4. Utilizing steam economically—in prime movers, heating and processing.
5. Recovering condensation.

This article has in view the emphasizing of simply one element—that of steam economy in processing material and how it may be greatly increased by the application of temperature control.

It is now conceded that fuel, raw materials, and labor will probably continue at war level prices, or higher. The need for exercising every precaution against any waste is therefore more necessary than last year.

It is no exaggeration to state that practically all equipment using steam, whether live or exhaust, in processing raw materials, should be so controlled that the amount of steam used is governed by the artificial temperatures required to produce the finished article or commodity uniformly. There is nothing novel in this. A number of processes have used automatic temperature control for years. Lumber drying, food processing and milk preparation are well-known instances of the advantages and necessity of such control.

There is much to be done, however, and manufacturers everywhere are recognizing that lack of reliable temperature regulation results continually in waste material, high production cost and, obviously, products they cannot consistently guarantee.

Not only does temperature control in most cases release labor for other work, but it necessarily saves steam or whatever medium is used in processing, and above all, the results are uniform.

It would be difficult to name a product in which steam or a cooling medium has played an important part in its manufacture, that is not improved by automatically controlling the temperature during the process. Nevertheless, it is a fact that there are many plants using antiquated methods of hand control simply because it has not been brought to their attention that reliable regulators may be purchased and with them all uncertainty eliminated.

No engineer would think of designing a public institution and not including automatic temperature control of the heating system. Everyone is familiar with this and the reason for the wide use of these systems is obvious. It has been demonstrated that at certain temperatures the average person is most efficient. Other temperatures while not necessarily injurious, are detrimental and long exposure to them certainly results in damage of some sort, although this might not be apparent for a long time.

The same reasoning applies to manufactured articles. Widely varying temperatures in processing undoubtedly are the reason for apparently inexplicable failures after an article has been in service.

While it is true that instruments or mercury thermometers indicating temperatures should be almost dead accurate, it is not essential in most manufacturing operations that the temperature control be so close. Usually it suffices, if the temperature can be held within two or three degrees from that desired. With such controls the human element can be discarded and the manufacturer assured that no material is wasted, the finished product will be practically uniform and produced within the estimated unit cost.

Much has been written of co-operation and the large number of important industrial firms now operating on this basis testify that it is good business. It seems pertinent, therefore, to point out the fallacy of requiring the steam producing departments to be economical and then wasting the steam at other points in the factory. If the boiler-room force knows that the manufacturing departments are exercising every precaution to avoid waste, it insures that co-operation so often lacking between these departments and without which the overall efficiency of a factory is seriously diminished.

Various instruments are placed in the boiler and engine rooms to insure proper handling of fuel and water and to maintain high efficiency. This is quite proper and it is true that the intelligent selection and use of these will increase economies. It is obvious that manufacturing departments using steam to produce finished articles should not be expected to secure uniform results if temperatures maintained are dependent upon hand manipulation of steam supply valves in accordance with thermometer observations.

Automatic temperature control should be used because—

Uniform temperature is possible at all times, day or night.

Steam waste is eliminated.

Material is not wasted or damaged through either under heating or over heating.

It is not necessary to depend upon hand control.

The personal element is eliminated.

Uniform product is assured.

Material processed regularly at temperatures demonstrated as correct stands up in service.

Complete Coal Pulverizing and Transport System

FOR PREPARING, transporting and burning powdered fuel, this complete fuel system has been developed and successfully applied to boilers and industrial furnaces. In preparation, the fuel progresses through several stages which are controlled by automatic devices. It is claimed that the plant requires little attention.

In this system the fuel pulverizing plant may be located with relation to the point of coal supply, and the fuel distributed to furnace hoppers at widely separated points, it is said, regardless of obstructions.

From the car on the siding, as shown in Fig. 1, the fuel passes through a crusher, A, and then is elevated to a magnetic separator, C, where tramp iron is removed. Passing through the crushed fuel bin, D, it is next fed to a rotary drier, G, and carried to the dried fuel bin, K. The fuel then feeds automatically to the pulverizer, L, from which it is carried through the collector, M, into the pulverized fuel bin, N. In quantities desired, the fuel feeds through the dust-tight gate, P, and inlet valve, R, into the blowing tank, Q, alongside of which is a scale dial to indicate the amount of fuel available for transport.

Now ready for use, the fuel passes through the shut-off valve, SO, and enters the transport line, T. Fuel in bulk is transported by compressed air from the pulverizing plant through small diameter wrought iron or steel pipe to the furnace lines. The air pressure is applied on top of the mass of powdered fuel in the blower tank.

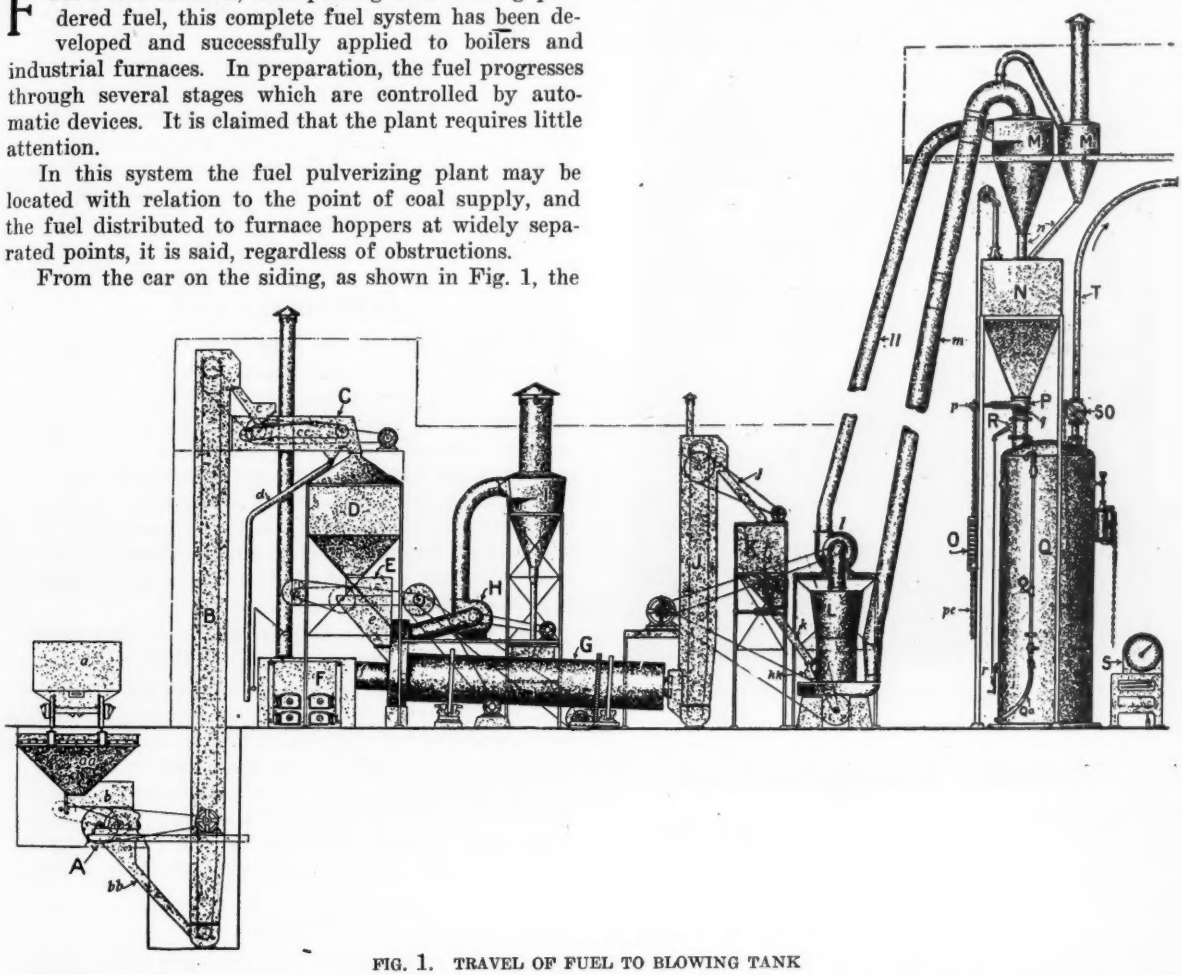


FIG. 1. TRAVEL OF FUEL TO BLOWING TANK

For diverting fuel from the transport line a specially designed switching valve is employed, which may be hand operated or furnished with semi-automatic or full automatic control. With the semi-automatic control, a predetermined amount of fuel for each individual furnace bin may be transported by the operator at the blowing tank. In the full automatic switch control, a special device at each bin automatically sets the switching valve when fuel is needed, and a signal lamp at the blowing tank notifies the fuel distributor. When the proper amount has been transported to the bin, the signal lamp is turned out and the valve is automatically reset to the line.

After being discharged from the furnace bin, the fuel passes through a dust-tight gate and enters the fuel feed controller, which is equipped with a hand wheel, as shown in Fig. 2, to secure any range of control from minimum to maximum. Any number of controllers may be operated in multiple by countershaft or connecting shaft, and still insure individual feed control for each burner. Although the feed screw is driven at constant speed, adjustment of feed control is accomplished by means of a pair of shutters closing around the screw to provide an adjustable outlet leading to the controller discharge head. An agitated screen placed in the discharge head causes the fuel to be showered

into the ejector. It is claimed that the vacuum ejector principle creates a parted vacuum in the controller discharge, preventing bridging of fuel in the bin.

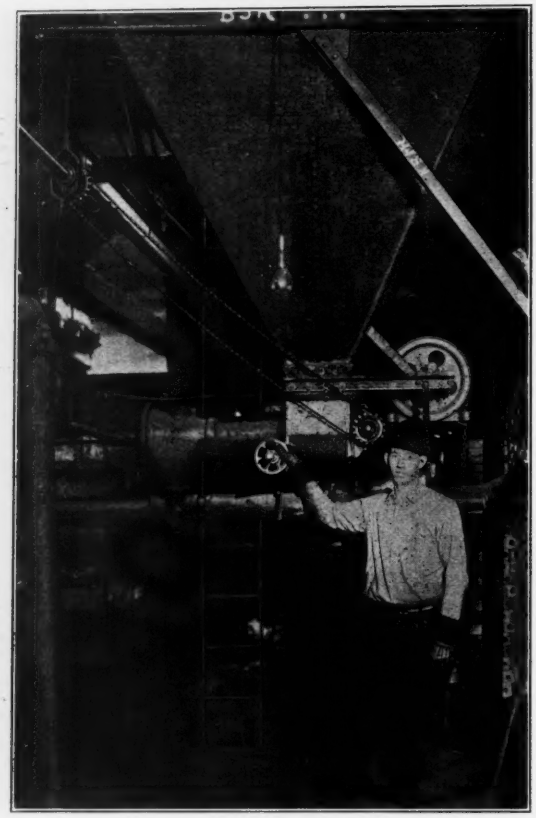


FIG. 2. FURNACE BIN AND FEED CONTROLLER

Mounting Tracings on Cloth

TRACINGS supplied to engineers and others require mounting on some untearable material before they can be sent to the works, where they are likely to receive rough usage.

Calico suitable for this purpose can be bought in 30-in. width, and a simple method of mounting is as follows: Stretch the piece of white calico, about 2 in. wider than the tracing to be mounted, by tacking the cloth tightly on a board, allowing about 3 in. between the tacks. Then sponge well over with water to draw out any creases that may be found in the cloth. Place the tracing, face side down, on a clean board. Dampen it well by passing a moist clean sponge or wide brush round the edges about 2 in. on; afterward, thoroughly dampen the entire surface, except the edges. Other methods of dampening may answer equally well; but it is necessary to observe that the edges of the paper shall not be quite so damp as the other portion.

Next take some good homemade or commercial (dextrine) paste, not too thick, care being taken that no lumps or hairs are in the paste, so that an even surface may be obtained during the pasting operation. Carefully apply the paste to the surface of the calico with a brush; then with the help of an assistant lay down one side of the tracing for about the width of 6 in. The tracing should be held by the assistant above the surface of the calico at an angle of about 45 deg., while the tracing is pressed down about 6 in. at a time, by placing the palms of the hands in the middle of the paper, and gently smoothing towards each edge until the whole is laid down; then take several large sheets of strong blotting paper, rub the tracing gently and evenly over the whole surface. The blotting paper should be held firmly with the left hand and rubbed with the right.

After the rubbing, it will most likely be found that the tracing has blistered in parts, owing to the entrained air beneath the surface. These blisters must be pricked with a fine needle and then rubbed down as before. The blotting paper should then be laid over the whole surface and a drawing board laid over it, weighted down, and left for several hours to dry.

Americans All

THERE MUST be no sagging back in the fight for Americanism merely because the war is over.

In the first place, we should insist that, if the immigrant who comes here does in good faith become an American, and assimilates himself to us, he shall be treated on an exact equality with everybody else. But this is predicated upon the man's becoming in very fact an American—and nothing but an American. If he tries to keep segregated with men of his own origin and separated from the rest of America, he isn't doing his part as an American.

We have room for but one flag, the American flag, and this excludes the red flag, which symbolizes all wars against liberty and civilization just as much as it excludes any foreign flag of a nation to which we are hostile. We have room for but one language here and that is the English language, for we intend to see that the crucible turns our people out as Americans, of American nationality, and not as dwellers in a polyglot boarding-house; and we have room for but one soul loyalty, and that is loyalty to the American people.—THEODORE ROOSEVELT.

AN ORGANIZATION has been arranged of the Office of Director of Sales of the War Department, with a personnel made up as follows: Director of Sales C. W. Hare has an assistant, E. C. Morse, who serves as chairman of the Board of Sales Review. This board is made up of Division Sales Managers and Capt. T. S. Schultz, who is legal member on the board. The divisions are as follows: Machine tools, including steam shovels, cranes, hand tools and the like, in charge of Colonel LaMar; building material of all kinds, including electrical equipment and refrigeration apparatus, Maj. W. M. Crunden; trucks and motor equipment, including animal and hand-drawn vehicles, Col. Fred Glover; quartermaster stores of all kinds, Mr. L. H. Hartman; real estate, Mr. G. F. Woods; raw materials of all kinds, Capt. A. L. Mercer. There is, also, a department of ordnance supplies, including artillery, guns and all manufactured munitions, but the division head has not yet been named.

Economy of Steam Jet Ash Conveyors

OUTLINE OF SYSTEM; RESULTS OF TESTS; DETAILS OF FITTINGS. BY GUY S. HAMILTON

THE boiler plant of a certain ice and coal company is equipped with three 200-hp. return tubular boilers from which about 5 T. of ashes accumulate each day. A year and a half ago these ashes were wheeled out of the boiler room and were dumped about 35 yd. away from the plant. The ashes were later shoveled into wagons, sometimes as many as three being employed at once. The expense item was excessive, so the chief engineer determined to reduce his ash disposal costs and made a careful study into the problem.

In place of the old system he installed a steam jet ash conveyor, about which he later wrote to an inquirer:

"We have been operating a steam jet ash conveyor for about 18 mo., and from the time we started the system operating we have saved from $3 to $3.50 a day in handling our ashes. Now we have a truck which comes to the chute of the ash tank and in about 3 to 5 min. it is loaded and gone. The tank is cleaned out in three or four loads."

CARRYING CAPACITY AND STEAM CONSUMPTION OF TYPICAL STEAM JET ASH CONVEYOR

Boiler Number	Distance from Ejector	Steam Pressure	Quantity of Ashes Moved	Time	Tons Per Hour	Pounds Steam Used Per Min.	Steam Used Per Ton Ashes Moved	Cost of Steam Per Ton Ashes Moved
1	4 ft.	110	300 lbs.	1' 0"	9.00	37.43	249.3	$.068
2	10 ft.	109	292 lbs.	1' 0"	8.79	37.10	253.2	.07
3	35 ft.	109	284 lbs.	1' 0"	8.46	37.10	274.9	.078
4	52 ft.	108	234 lbs.	1' 0"	7.04	36.85	314.0	.088
5	64 ft.	109	210 lbs.	1' 0"	6.30	37.10	353.3	.098
Average	34 ft. 8 in.	109	264 lbs.	1' 0"	7.92	37.11	289.0	8.080

Distance from Ejector to Bin 112 ft. 0 in.
Total Length of Line 178 ft. 0 in., Size 8 in. Standard.
Plant handles approximately 20 Tons Ashes per 24 hours.
Using Chain Grate Stokers. Burning Illinois Screening Coal.
Cost of Steam 28c per 1000 lbs.
Steam measured with Flow Meter.

The conveyor consists of a line of pipe into which ashes are fed and through which they are carried to a discharge point by current action. This current is created by the action of a jet of steam discharged at high velocity into the center of the pipe line in the direction of the travel of ashes. This steam discharge tends to create a vacuum behind it, which in turn creates a current of air through the air intake in the line.

Ash intakes are located conveniently before the ash pits so that the firemen can rake the ashes into the intakes with the least effort. The suction pulls the ashes through the system toward the steam unit fitting, that point where the steam is introduced into the system. Here the force of the steam itself ejects the ashes through the remaining, or discharge line of the system. As the fireman draws his fires, he opens the valve, allowing the steam to enter the system. The ashes are then shoveled or raked into the intake tees where the suction whisks them away to the small tank outside. From here the ashes are withdrawn from time to time and carted away.

There has been an assumption on the part of many engineers that the steam ash conveyor is expensive to operate. Without investigating carefully this phase of operating expenses, they have jumped to conclusions. The fairest method of comparison of the steam ash conveyor with mechanical methods is to figure the cost per ton of ashes moved. The power should always be figured back to pounds of steam at the boiler, taking into consideration all losses from the boiler to the point of application. The ashes are moved so quickly that the cost per ton of ashes handled is quite reasonable. The secret of keeping down steam consumption lies in the proper use of the nozzle.

The size of the nozzle should never be determined by guess, but by actual scientific test when the conveyor is started in operation. The ashes from the boilers should be examined and weighed; mercury readings taken to test the system; and the suction created, recorded. By actual experiment the nozzles should be tested out until the proper size is found.

As an instance of the economy of the steam consumption, take the case of a certain boiler plant where there was installed a steam ash conveyor the total length of

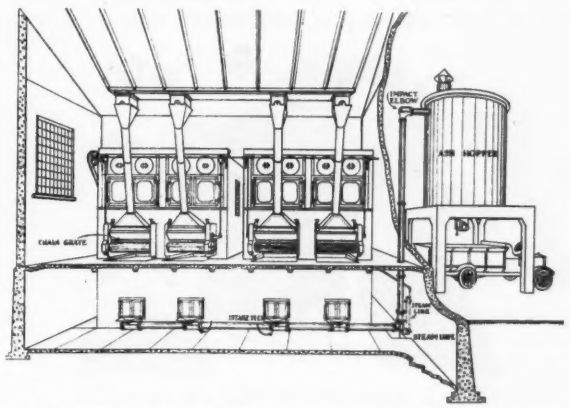


FIG. 1. STEAM JET ASH CONVEYOR INSTALLATION IN STOKER FIRED PLANT

which from an intake to discharge point was 178 ft. The distance from the ejector to the bin into which the ashes were discharged was 112 ft.—considerably greater than the average discharge line.

The ashes from each of the five boilers were discharged and timed. The amount of steam used was measured with a flowmeter. As a result of this investigation it was discovered that the average cost of steam per ton of ashes moved was but 8c. A table showing the individual cost of each boiler and the average of the five is given herewith.

An additional thought on the subject of economy of the steam ash conveyor relates to the low upkeep costs experienced by users of this type of ash handling equipment. This is undoubtedly due to the use of extremely hard metal conveyor lines and fittings. Ordinary cast iron pipe is entirely too soft for conveyor use as the ashes bite into this kind of metal and soon wear it away. The additional use of liners or wear backs at vulnerable points in the conveyor fittings keep the replacement charges down.

The steam unit fitting of one manufacturer has three patent liners of especially hardened metal. The first is

a heavy impact liner located directly above or across from the inbound opening at right angles to the flow of material. The other two are throat liners which protect the fitting to the discharge flange so that the complete discharge opening of the fitting is reinforced against wear. The inner throat liners will resist the wear of several thousand tons of ashes before having to be renewed. Their life depends largely on the nature of the ash and the layout of the system.

Another ingenious feature about this fitting is the safeguards taken to protect it. Should the liner wear through, the top cover plate of the fitting takes up the wear, thus becoming in fact a secondary liner. Since this is easily renewable no damage is ever done to the body of the fitting itself.

The clean lines of the steam conveyor lead many to believe that the engineering involved in the design and layout of a conveyor system is small. Such is not the case. Every boiler room is different. Every system installed involves different engineering features which only an engineer of wide experience can successfully meet. To install a system that will operate quickly and at the same time be economical not only in first cost but also in operation, calls for a display of considerable ability. A wide

FIG. 2. PARTS OF A 90 DEG. STEAM UNIT

choice and skillful arrangement of steam unit fittings is necessary if every boiler plant requirement is met.

The wise engineer or power plant executive will call into consultation engineers who have specialized in the designing of ash disposal equipment. Only by so doing can they be certain of securing the utmost in economy and efficiency in steam ash conveying or any other type of equipment.

Tales of a Flying Engineer

"BARRACKS flying" is the supreme indoor sport at many flying fields. Immediately after "lights out" seems to be the official hour, and over in one corner of the cadet barracks one of the more advanced flyers will be heard telling a bunkie "how to bring her out of a spin quickly," or details of a neatly executed forced landing while on his "cross country" and the pretty girls who greeted him, or about the execution of some maneuver.

It is all intensely interesting to the new cadets, but some unfeeling, calloused veteran soon tires and calls out, "all right, Gunemyer, come on down, bring in the ship, and close up the hangar." Then shouts of "off" or "contact," according to various sympathizers, snickers, witty comments flung across the room, and soon unbroken silence comes. Thus ends the flight.

But barracks flying is not without its benefits. As a flying cadet I knew how to loop long before arriving at the acrobatic stage. On numerous occasions, I had listened intently to informal explanations, such as, "Now all you do, Joe, is first nose her down and gain plenty of excess speed, then pull the stick all the way back, easing it forward to level out as you come down; say, it's dead easy, Joe, just wait till you try it."

From my office I have just seen a Victory Loan flyer doing power spirals around the Blackstone Hotel, heard the hum of his motor and imagined a sniff of gasoline.

And now, back at the desk, my mind frequently goes wandering back to those happy, breezy old days in the air and amusing nights in the barracks. With a slide rule as my "stick," and my heels on the chair legs as a rudder, an easy "take-off" occurs for my flight in fancy. For the present, my "Kent" is pushed aside—kilowatt ratings and boiler feed pumps are forgotten—I am again enjoying a little barracks flying.

Metal Beams and Girders in Masonry

A SPACE for expansion should always be left at the ends of all metal beams and girders entering the walls or other parts of a brick or stone building, because in the event of a fire the expansion of the iron will push the walls out and cause a general collapse, such as was the case at a large store in West London a few years ago. It is the safer plan to use cast-iron boxes for the ends of the beams and girders to run in, and to allow from 3 to 6 in. for expansion, according to the length of the beam or girder.

STEAM ENGINES. By E. M. Shealey; 290 pp., illustrated; 6 by 9 in., New York, 1919; cloth, $2.50.

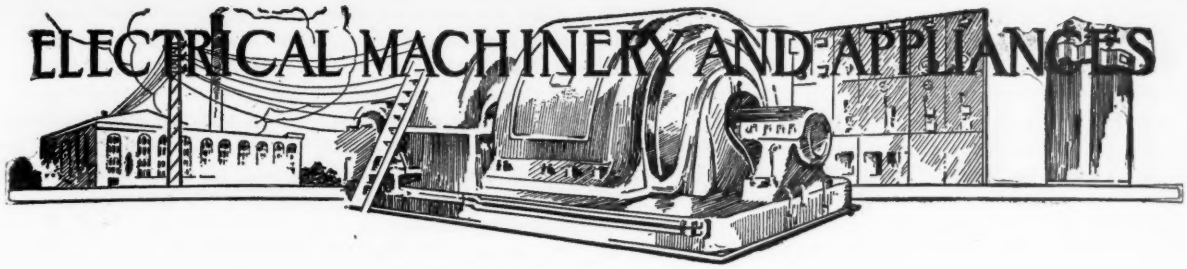
Prepared as a text book in the correspondence extension courses of the University of Wisconsin, this is well adapted for the beginner in the field and for isolated individual reading. The author starts with the elementary principles and parts of the engine and leads up through the action of the plain slide valve to the Corliss and other complicated types.

On the mechanical side, the construction of typical details is shown and adjustments explained. On the technical side the action of heat, properties of steam, use of steam tables, testing by indicator and brakes and reading of cards are treated sufficiently for practical purposes.

A brief discussion of the valve diagram and its application and quite a full explanation of valve gears and valve setting follows, covering shifting eccentrics, Meyer and Corliss valves and reversing gears.

A chapter on Governing, one on Compound Engines, one on Condensing Apparatus and one on Lubrication complete the volume.

The book is sound in its treatment of the various subjects, the author has kept well in mind that he is writing for those who are starting the study of steam engine practice, and has produced a book easily read and understood. The information, as was inevitable in covering so wide a range of subjects in limited space, is sketchy, but will serve well as an introductory first step, and gives a good basis on which to build for more detailed study.



Improved Methods of Shop Lighting

ADVANTAGES OF THE GENERAL OVER THE LOCALIZED SYSTEM OF ILLUMINATION. REFLECTOR EQUIPMENT FOR HIGHER INTENSITY UNITS. RESULTS OF APPLICATION.

WHY should shop illumination be so important? In brief it assists in increasing production, decreases accidents and lessens eye-strain. It makes general surroundings more cheerful, results in better order and is conducive to effective supervision. Not only does modern efficient lighting improve working conditions, but in many cases where correct lamps replace obsolete types, it actually reduces the lighting cost.

There are some factors, such as more efficient machinery and better trained workmen which are essential to improving the overall economy of the shop. Lighting and ventilation are two factors not so apparent, but whose value has never been fully realized until recent years, when more intensive study of the economies of plant operation has come into vogue.

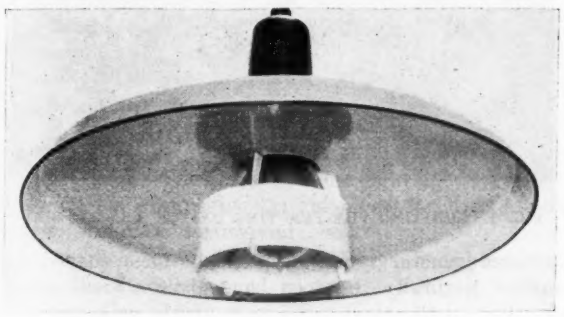


FIG. 1. 300-WATT STEEL REFLECTOR UNIT WITH OPAL GLASS EYE-SHIELD

Illuminating engineers are now receiving greater consideration from factory owners, managers and designers because of the proven successes of modern lighting methods. In addition to creating improved lamps they have developed efficient reflector equipment. They have made intensive studies of the various lighting needs of industrial plants which have proved extremely valuable in raising the standard of artificial illumination.

For indicating light intensity, the unit foot-candle is commonly employed. It is the lighting effect produced upon an object by a standard candle at a distance of one foot; at two feet the effect would not be one-half foot-candle, but one-fourth foot-candle. The table gives the illumination requirements as issued by the Illuminating Engineering Society and subsequently adopted by the United States Bureau of Standards for the National Safety Code and government plants.

A recent survey of 93 Chicago shops showed an average light intensity of 1½ foot-candles now in use with variations from 0.01 to 10 foot-candles, and an average consumption of 0.33 watts per sq. ft. For these same plants the conservative Illuminating Engineer's Society code shown in the table, would provide an average intensity of 5.5 foot-candles, the intensity would vary from 2 to 12 foot-candles, and the average watts per square foot would be 1. This clearly indicates the inadequacy of intensity judged by a conservative official standard.

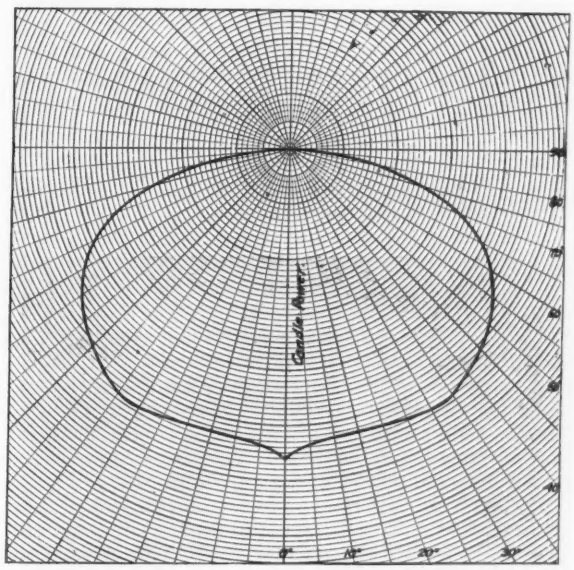


FIG. 2. DISTRIBUTION CURVE OF 300-WATT EYE-SHIELD UNIT

During a recent trip through a large Illinois railway power plant, a visitor was impressed with the extreme lack of suitable illumination. About one-half of the proper light was furnished in the engine room, and the only illumination in a dark gloomy boiler room came from the lamps mounted on the boiler gages. It seems incredible that such neglect could occur at the very source of lighting current. Such plants invariably receive from engineers and firemen only the half-hearted uncertain action that is possible under the faulty conditions.

METHODS OF ILLUMINATION

LOCALIZED lighting using drop cords was the first

method of shop lighting. It still has its advantages for certain operations, but is fast being superseded by general illumination with more efficient and larger lamps. Local lights frequently produce glaring conditions. An operator will not take time to place the lamp with its reflector so that the direct rays of the reflected light from highly polished working surfaces will not strike his eye. Breakage of lamps is apt to be high, and the cost of wiring is greater than necessary.

Extremely fine work or special operations, such as internal boring in machine shops, may compel the installation of drop lamps. They should, however, always be supplemented with general illumination.

LIGHTING INTENSITIES REQUIRED IN INDUSTRIAL PROCESSES

	Foot-candles at the work	
	Normally	Minimum
Roadways and yard thoroughfares	0.05- 0.25	0.02
Storage spaces	0.50- 1.00	0.25
Stairways, passageways, aisles	0.75- 2.00	0.25
Rough manufacturing such as rough machining, rough assembling, rough bench work	2.00- 4.00	1.25
Rough manufacturing involving closer discrimination of detail	3.00- 6.00	2.00
Fine manufacturing such as fine lathe work, pattern and tool making, light colored textiles	4.00- 8.00	3.00
Special cases of fine work, such as watch making, engraving, drafting, dark colored textiles	10.00-15.00	5.00

Lamp Construction

Carbon lamps should be replaced by the modern drawn tungsten filament or other efficient lamps. This substitution will result in a decided saving of current for a given candlepower.

For comparatively small lamps of low intensity, the air is withdrawn from the glass bulb, hence these are often referred to as vacuum lamps. In larger lamps, ordinarily above 100 watts, the air is removed and then an inert gas, or mixture of inert gases, is introduced in the bulb at atmospheric pressure. This form is occasionally described as the gas-filled lamp.

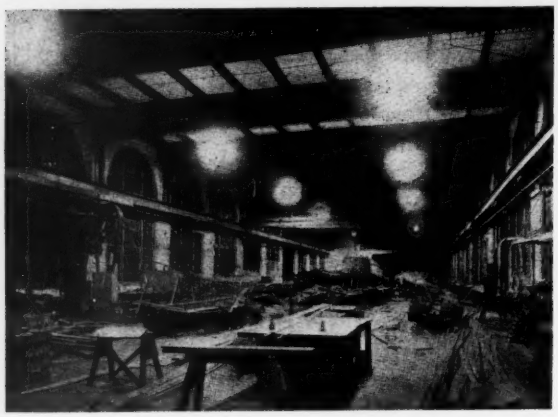


FIG. 3. ILLUMINATION IN WOOD WORKING SHOP WITH 750-WATT UNITS

Evaporation of the filament is retarded by the action of the gas, and permits of a higher operating temperature. The higher the temperature of the lamp filament, the greater the amount of light produced for a given current consumption; the emitted light is also nearer white in color. Cooling the filament is a secondary action of the gas, which tends to affect its good qualities. This action makes it uneconomical to employ such a construction in lamps of low wattage.

Mercury vapor lamps afford an even distribution of light and have been adopted by a number of large factories, particularly automobile plants. These lamps emit a peculiar greenish light which some consider quite restful to the eye.

Reflector Equipment

Reflectors have two purposes: to distribute the light most efficiently on the working plane and to protect the eyes of the workmen. Glare in the eyes due to unshielded lamps should be rigidly avoided. Not only does it produce a serious effect upon the eyes, but also produces a tiring effect upon the entire body. Proper reflector equipment will avoid such an effect.

Steel reflectors are now recognized as standard industrial equipment, and are most commonly employed with a white porcelain enamel finish. They are made in three general types, deep bowl, dome shaped and angle. Naturally the deep bowl gives a lower cutoff; in other words, the lamp is not visible at as great an angle as when used in the dome reflector. This fact tends to reduce the amount of light on vertical surfaces and gives an excellent light on the working surface, although general distribution is less satisfactory.

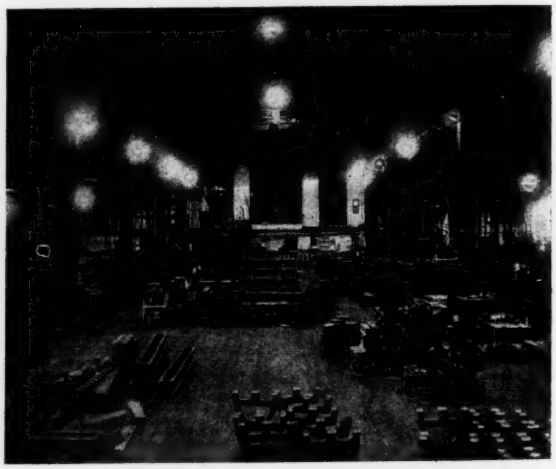


FIG. 4. LIGHTING THE ERECTING BAY OF A LARGE SHOP

Dome reflectors distribute the light through a considerably wider angle, and if properly designed, have a sufficient cutoff to shield the eye. Experience has indicated that the dome type porcelain enamel steel reflector with a bowl-frosted lamp is a favorable industrial lighting unit for the average conditions.

As the name implies, the angle reflector is of the deep bowl shape, with its holder set at an angle to the axis of the lamp. Such equipment is useful when particularly high illumination is required on vertical surfaces, or where lighting units must be located along the side walls.

There are a number of specially designed units for industrial lighting. One of the best of these is known as the reflector-cap unit. A polished metal cap is held under the lower half of the lamp bulb to cut off the

direct rays of the lamp. The reflector itself is relatively large, and this combination gives excellent diffusion. Total output of light is reduced slightly by this special construction, and the cost of equipment is a trifle higher, but such a unit can be well installed where specially diffused illumination is required.

All of the types mentioned above are of the direct lighting type. Semi-direct and totally indirect systems are coming in vogue to a slight degree in industrial plants because of the distribution and diffusion qualities. They seldom prove practical in the general shop installation, however, because they are more susceptible to dirt and accumulation, and require relatively light colored surroundings for economical operation.

Increased Illumination and Production

One large lighting company has adopted specifications employing these general types of equipment for factory lighting: (1) Gas-filled lamps with steel dome reflectors and eye shields in the 200, 300 and 500-watt sizes. (2) Gas-filled lamps with deep bowl reflectors for extreme mounting heights. (3) Vacuum lamps and deep bowl reflectors for certain drop cord applications.

In using the eye-shield units, which are employed for wide spacings, it is of first importance that the shields be sealed in place and only removable by an authorized man. The ordinary workman wants more light, but knowing nothing of the effect of excessive brightness contrasts, is apt to remove the shield as a useless obstruction. Figure 1 shows a 300-watt eye-shield unit, the candlepower distribution curve of which is shown in Fig. 2.

As a result of a two months' productive intensity test, conducted in a machine shop with operations ranging from rough to fine, it was found that under an intensity of 12 foot-candles, production in several occupations was increased from 8 to 27 per cent over that of a previous period using an intensity of 4 foot-candles. In this instance, general lighting with deep bowl reflector equipment was employed for both intensities to eliminate commercial bias.

In another case where bare lamps had been employed, the installation of a general lighting system increasing the illumination 25 times, resulted in an increase in production ranging from 30 to 100 per cent in several operations of the shop. Replacing an obsolete system in another instance increased the illumination 25 times and the light current 7 times. Records of the lighting company's testing engineer showed an increase in production of 20 per cent at a payroll increase of 5.5 per cent.

Arrangement and Size of Units

It would be unwise to advance any set of rules for lighting which would apply to all industrial plants, due to the large variety of condition which should be considered. The type of materials handled, class of work, location of room, color or surroundings, ceiling height and location of apparatus all have an important bearing upon the lighting requirements and the particular system selected. When special requirements are to be met the problem of securing a satisfactory lighting system may well be referred to a lighting specialist.

Rooms having high ceilings lend themselves satisfactorily to large sized lamps, as it is practical to space the units considerable distance apart and still have even illumination without objectionable shadows. Figure 3 shows a woodworking shop with 750-watt lamps hung above a traveling crane. These are spaced on 40 ft. by 30 ft. centers and fitted with bowl-shaped steel reflectors. There is adequate general illumination for sawing, fitting and constructing without the use of individual lamps.

An erecting bay of a plant making machine tool is shown in Fig. 4. Fifty feet high above the crane travel is a row of 1000-watt lamps in deep bowl reflectors. On the columns, below the crane travel, are placed 300-watt lamps in angle type reflectors. In the side bays, which have lower ceilings, 150- and 200-watt lamps were employed in this instance.

In many shops it is necessary that only certain sections receive a high intensity light, while in the remaining area a low intensity will be sufficient. An instance of this is shown in Fig. 5, a night view of a large machine shop. Over the machines a localized-general lighting system is employed with 100-watt bowl frosted lamps in dome-shaped steel reflectors, 9 ft. high, and so spaced that approximately 1 watt per square foot is provided. Benches are illuminated by 60-watt lamps in deep bowl reflectors on 8-ft. centers between the vises and 5 ft. above the bench.

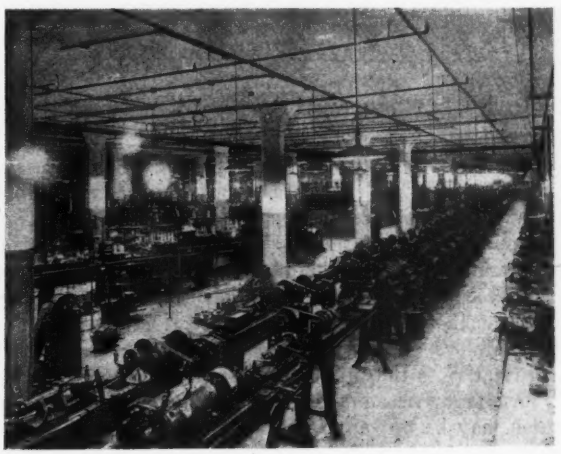


FIG 5. NIGHT VIEW OF A MACHINE SHOP, USING DOME-SHAPED AND DEEP-BOWL REFLECTORS

When the United States Shipping Board started its recruiting service for the purpose of furnishing American officers and crews for American merchant vessels, it was said by many experienced shipping men that it could not get Americans to go to sea. A report recently received by the Shipping Board from the Sea Service Bureau, of its recruiting service, which has charge of placing crews in American ports, covering March, 1919, shows that out of a total of 6985 placed by the Bureau on American ships during that month, fifty per cent were young Americans who have been fitted for their present vocation as merchant marines on training ships maintained by the Shipping Board. The report also states that 90 per cent of the officers on American vessels are now Americans.

Reversing Direction of Rotation of Single Phase Motors

By A. M. Dudley

SINGLE-PHASE motors in general are divided into four classes, namely, split phase, repulsion starting, shading coil and series motors.

Split-phase motors have two distinct windings, a main running winding and a high resistance starting winding which are connected to the circuit as shown in Fig. 1. The direction of rotation of the motor is reversed by interchanging the terminals of either one of these windings, but not both: i.e. *C* and *D* may be interchanged or *A* and *B* may be interchanged. The reason for the reversal is the same as in a two-phase motor, one of the phases is reversed by interchanging the leads.

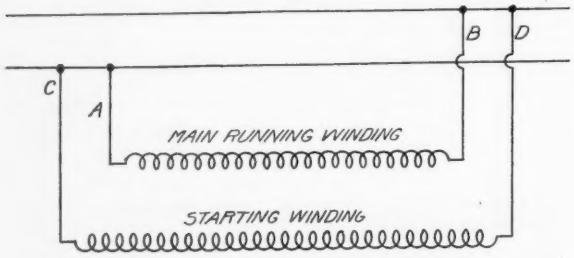
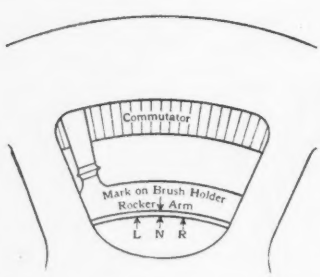


FIG. 1. SCHEMATIC DIAGRAM OF SPLIT PHASE MOTOR WINDINGS

Repulsion starting motors have an armature winding, a commutator and brushholder similar to direct-current machines, the brushholder being short-circuited through the rocker arm. Reversal of the direction of rotation of these motors is accomplished by shifting this rocker arm relative to the supporting bracket, as shown in Fig. 2. An arrow is stamped on the movable brushholder, which may be put opposite any one of the three marks on the stationary bracket. The middle one of these marks is known as the neutral and, when the brushholder is in this position, the motor will not start in either direction. When the brushholder is shifted to one side or the other of this neutral, as indicated by the marks *R* and *L*, in Fig. 2, the motor will run right hand or left hand, respectively.



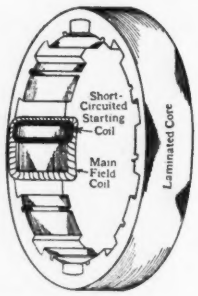


FIG. 2. ROCKER ARM OF REPULSION STARTING MOTOR
FIG. 3. MAGNETIC CIRCUIT OF SHADING COIL MOTOR

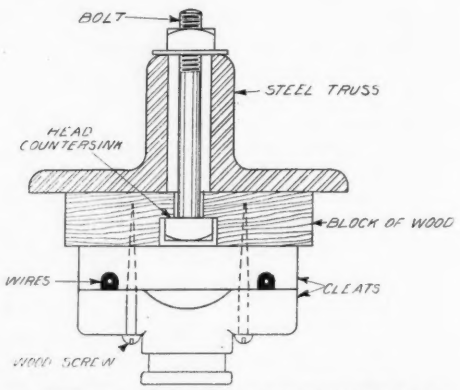
Shading coil motors have only a single winding connected to the line, and it is obvious that reversal of the terminals of this one winding will not reverse the direction of rotation, since the motor operates on alternating current. The obvious method of reversing the direction of rotation of such motors is to shift the short-circuited starting coils to the other side of each of the main poles. This, however, is quite difficult to accomplish and it is usually much easier to reverse the motor by taking off both end brackets and turning the complete stator end for end relative to the rotor; or else by taking out the laminated core with the windings in it, and reversing it end for end relative to the rotor.

Series motors of the commutator type are reversed by reversing the direction of current through either the armature or the field, just as in a series direct-current motor.—The Electric Journal.

Conductors on Steel Members

By C. Walker

IN modern steel-frame industrial plant buildings there is often occasion for carrying open-wire circuits along the roof trusses and other members. An economical and satisfactory method of accomplishing this is illustrated in the accompanying sketch. It consists in clamping, with through bolts, to the steel angle, struts, ties, or chords, a wooden block. Each block is bored for the bolt and is, in addition, countersunk so that the head of the bolt will lie below the surface of the block where it will not interfere with the mounting on it of the porcelain. To this block the porcelain cleats can be sustained with wood screws. Small receptacles or other wiring fittings can be mounted on these wooden blocks which are bolted to the steel members.



CLEAT ROSETTE MOUNTED ON TWIN-ANGLE MEMBER

The general scheme illustrated is that which has been used in many United States Army buildings which have been erected within the last year or so in various parts of the country.

Efficiency

It ain't a senseless hoardin'
Nor stinting of our need,
But efficiency in spendin'
That should become our creed.
It ain't some money set aside
On impulse once awhile,
But steady savin' day by day
That builds the solid pile.

—S. V. Perlman.

Application to Industry of Oxy-Acetylene Welding

WELDING and cutting by the oxy-acetylene torch has been an important factor of economy and efficiency in recent industrial progress. Starting as an obscure process, subjected to opposition and criticism, it has in a comparatively brief period of time taken its place as an indispensable resource of industry.

In the elimination of waste and as a saver of time and expense in all branches of industry the process stands by itself.

To enumerate all the various applications of the process would require a volume of itself. The list given below is intended to present merely its more general uses:

Aeroplane construction.—Welding water jackets to cylinder, valve cages to cylinder, of manifolds (intake, exhaust, and cooling), flanges to the manifold connections, spark plug thimbles, tubular sections for frame, splice plates, sockets to frames, aluminum crank cases, water tank.

Automobile industry.—Welding rear axle housings, defective gears and pinions, manifolds, shafts, steering posts, automobile bodies (aluminum and steel), tubing used in wind shields, etc., crank cases, transmission cases, wheels which are made of two stamped-out parts, mufflers, valve stems to valves, rims, repairing crank shafts, frames, extending frame to make a truck out of a car.

Copper Plate.—Welding manifolds, floats, kettles, vats, tanks, copper stills, and chemical ware.

Electric railway.—Welding of bonds, armor for shafts, worn boxes, motor housings, building in teeth of defective pinions and gears, reclaiming of broken trucks, welding air receivers on air-brake system, steel trolley wires, side frames.

Forge Shop.—Welding ornamental iron, complicated parts.

Foundries.—Steel foundry: Welding up of blowholes, porous spots, blocks, cutting of risers, gates and heads; welding moldings which are cast in parts. Cast iron foundry: Reclaiming castings.

Lead burning.—Burning of connectors on storage batteries, battery repairs, lead linings in vats, tanks, etc., lead-pipe joints.

Piping and gas main work.—Welding of steam, air, gas, oil, and water lines, welding for high pressure gas distribution, ammonia systems. Fittings, such as T's, Y's, S's, crosses, which are cut and welded on the job, meter connections for houses, traps, drip pots.

Plate welding.—Ammonia receivers, generators, air receivers, tanks for oil, vacuum driers, digesters, vats, steam driers, tanks of all kinds which are to be subjected to heat and pressure, plate assembly work for gas manufacture by-products recovery work, stills.

Power plant maintenance.—Building up worn or broken parts, welding of cylinders, pistons, valve chests, etc. Welding of steam lines, of pump castings broken in service. Repairing of flywheels.

Railroad repair. — Firebox repairs (including patches), replacing side sheets, welding in flues, cutting off rails, mud rings, welding cracked steam chest, valves, crossheads, cylinders, building up worn pins, cutting out links, irregular shapes of steel, filling worn spots on wheels, welding spokes, cutting and welding up locomotive frames. Welding together two parts of car seats, chair and window frames. Reclaiming bolsters, couplings, slotting forged engine rods; building up frogs and diamond crossings, scrappings, building steel cars.

Rolling mill.—General repair of engines, rolls, hot beds, plates, furnace equipment, fabricating open-hearth water jacket doors, reclaiming copper tuyeres, cutting up lost heats, cutting up "kindling" or scrap, bar stock billets, plates.

Sheet metal.—Manufacture of metallic furniture, steel barrels, transformer cases, range boilers, kitchen utensils, light air tanks, tubing, oil storage tanks.

Shipyards.—Cutting of plates, channels, special sections, welding and reclaiming of broken parts of machinery and propellers, patching of hulls, stringers, building up of worn chocks.

Small arms manufacture.—Reclaiming component parts, spot hardening of different parts.

Structural steel.—Cutting as applied to coping, splicing and fitting rails, channels, I beams and other shapes. Cutting holes for rivets, welding up misdrilled holes, cutting of all kinds of gussets and splice plates, cutting wrecking, welding structural parts where riveting is not possible.—From Bulletin No. 11, Federal Board for Vocational Education.

Coating Cast Iron with Aluminum

IN METALL und Erz, reference is made to a process for covering the surface of cast iron with aluminum, which is said to have answered well in practice. The iron is first galvanized or coated with tin, and is then immersed in a bath of melted aluminum, at a temperature of from 700 to 800 deg. C. The surfaces are meantime scrubbed with tin brushes, and the tin or zinc on the iron becomes incorporated in the melted aluminum, and thus the iron becomes coated with the aluminum instead. The coating thus formed is said to adhere very firmly.

SEEMINGLY empty gasoline tanks or cans are at all times more dangerous than those filled with gasoline. Usually the can will not be entirely emptied and the remaining gasoline will vaporize, the vapor will mix with the air in the can, and the mixture may easily be explosive. When the can is being filled this mixture is forced out by the gasoline and may explode if ignited by a flame or spark near the opening. Many engines are built with cavities or inclosed spaces in the crank case, base, or some other part, and these may be full of gasoline vapors. When inspecting or making repairs with an open light, men have been severely burned when the light vapors ignited. To guard against such accidents, all cavities should be blown out with compressed air or steam. If neither is available the cover should be removed, the vapors fanned out, and a lighted lamp or candle, attached to a stick, passed around inside the cavities to burn out any vapors that may remain in the cavities. Unless an ample current of air at considerable velocity is passing, gasoline should not be used to clean an engine or other machinery. Even if there is sufficient air to sweep away the vapors as soon as they are given off open lights should always be kept a safe distance and on the intake side so that the vapor cannot be carried to the light.—SCIENTIFIC AMERICAN.

Defrosting

FROST ON REFRIGERATING COILS IS LIKE SCALE IN A BOILER. HOT GAS AND SPRAYING ARE THE QUICK EFFECTIVE METHODS OF REMOVING IT. BY A. G. SOLOMON

ANY engineer will answer quickly and positively when questioned as to the loss caused by dirty boilers. He will dwell at length on the per cent of fuel wasted owing to the thickness of scale on the internal surfaces of a boiler; and the loss directly due to accumulated soot and dirt on the external surfaces will be discussed in a manner that will be most convincing.

Scale and soot are insulating material and their removal means constant watchfulness and work on the part of the engineer and his crew.

Engineers who are worthy of the name will gladly allow visiting men of their profession to take a look inside of a boiler that is laid up for cleaning; and they take a great pride in calling attention to the small amount of scale. This is just as it should be. If you are fortunate enough to be invited to look over the entire plant, as well as the engine and boiler rooms, make a mental note of points where excellent insulation is doing

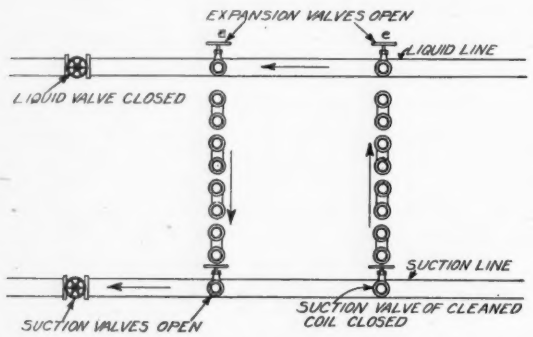


FIG. 1. POSITION OF VALVES FOR PUMPING LIQUID OUT OF ONE COIL INTO ANOTHER

its harmful and fuel wasting work in a quiet and undisturbed manner.

FROST IS LIKE SCALE

AMMONIA condensers are usually kept free of scale for the simple reason that if the insulating effect is allowed, the high pressure gage will show it plainly; but in nearly every refrigerating plant ice and frost are allowed to accumulate on the coils in ice vaults, cold storage rooms, freezers and coolers of all kinds. This condition is not limited to direct expansion coils only, but is found just as often in plants where the brine circulating system is in use. To prevent, as far as possible, the loss in refrigerating capacity due to this insulation, some means to remove the ice and frost must be provided.

Scraping the coils or knocking the frost off is a slow and very unsatisfactory job. Even after a careful job of scraping and knocking has been done, a thin coating of ice is still left. This thin coating can well be likened to thin hard scale on the boiler tubes.

To clean direct expansion coils properly a defrosting system must be used. In large sized plants having many cold storage rooms with direct expansion coils in each the defrosting system will be no more complicated than if there are only a few rooms. Of course, defrosting on a large scale will require considerable attention and care; but when systematically carried on, it is simple. Just how defrosting is accomplished can easily be understood when one considers the relation that temperature and pressure of saturated ammonia vapor bear to each other.

PRINCIPLES OF DEFROSTING

WHEN a frosted coil in a cold room is to be defrosted, the first step is to imprison the ammonia that is in the coil. This is done by closing the expansion valve and also the suction or outlet valve. Every direct expansion coil should be provided with a valve at the point

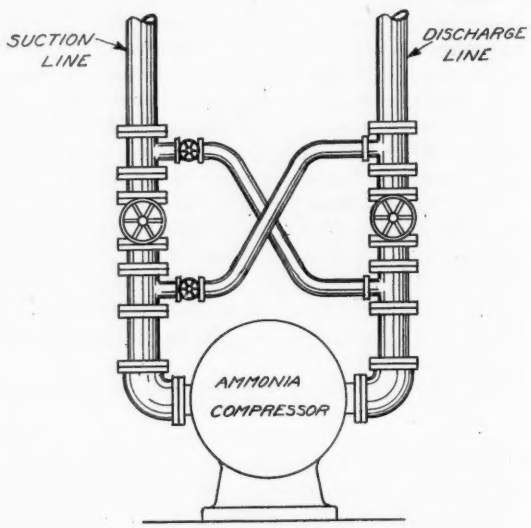


FIG. 2. REGULAR CROSS CONNECTION OF LINES AT COMPRESSOR

where the coil connects into the line leading to the compressor. Next the ammonia for defrosting is introduced. The saturated ammonia vapor already in the coil becomes heated by the absorption of heat carried in with the ammonia used for defrosting. This heating causes a rapid rise in the pressure with a corresponding rise in temperature. Always bear in mind that pressure and temperature of saturated ammonia vapor are functions of each other. Increased pressure necessarily means increased temperature.

While the frosted coil was filled with ammonia subjected to a pressure of 10 lb., the temperature inside the coil was about 8 deg. below zero. Now when this saturated vapor is imprisoned by the closing of the valves, the pressure will rise slowly. To make the pressure rise rapidly, ammonia of a higher temperature is admitted. When the injected heat has caused the pressure to reach 50 lb. the temperature inside the coil is about 32 deg. above zero.

Dry superheated ammonia gas is best for this heating effect, but liquid ammonia can be used.

A Simple Process

We will first look into the most simple form of defrosting. This does not require the installation of any valves or additional pipe work.

To remove the frost from a coil, it is just necessary to close the valve at the outlet of the coil and then open the expansion valve a little more than is usual in regular operation. The pressure in the coil will gradually rise, as the ammonia already in the coil will absorb heat units from the comparatively warm liquid coming in.

The ammonia in the coil will remain saturated throughout this defrosting process, as liquid will be passing through the expansion valve. When the frost begins to fall from the pipe, the coil will be filled with ammonia in a state of saturation so dense as to be almost liquid.

When the frost has been removed the greatest care possible must be exercised in opening the suction valve.

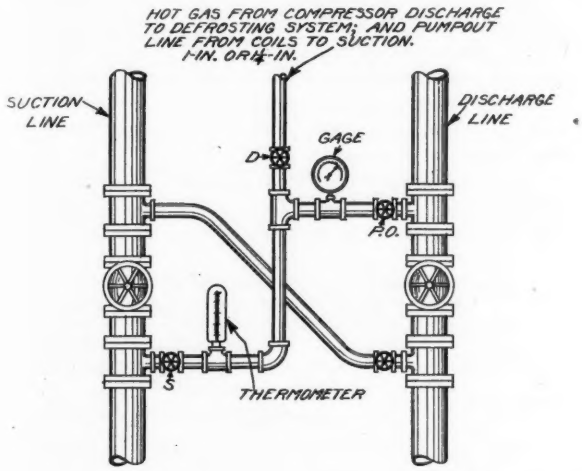


FIG. 3. CROSS CONNECTIONS ADAPTED FOR DEFROSTING

The ammonia in the coil must be drawn out by the compressor and, if the suction valve is opened quickly or too wide, the liquid will cause pounding if not serious damage.

If the coil is to be emptied through the outlet valve, the safe way is to open the valve just enough so that the ammonia can be heard passing. Leave the valve in this position long enough to be sure that the liquid is all out. This will be known by a light frost appearing on the coil or by the absence of sound at the partially opened outlet valve. Another way to pump out the loaded coil is by way of another coil whose expansion valve connects to the same branch of the liquid line, Fig. 1. Shut the cutoff valve on the liquid line and allow the ammonia stored in the defrosted coil to pass back through the expansion valve and then through the expansion valve of the other coil. This will be found to be excellent practice, as danger of flooding the compressor is reduced to a minimum.

When defrosting in this manner, the coil must be watched for signs of leakage. If the outlet valve is allowed to remain closed too long, the coil will become filled with liquid and the pressure will be the same as the pressure in the condenser. Often the flanges of the evaporating coils are not pulled up very tight and when the pressure becomes excessive, leakage is likely to start. Flanges that hold tight when the coil is in ordinary operation and is filled with vapor at a low pressure will generally leak when the coil becomes filled with liquid.

This method of defrosting is not recommended for a plant having more than 2 or 3 direct expansion coils. In the first place, it is too slow and is also somewhat dangerous. Another objection is that too much liquid ammonia is stored and this storing will cause a noticeable effect on the efficient operation of the rest of the system.

Hot Gas Defrosting

Hot ammonia gas direct from the compressor discharge line is the proper thing to introduce to the frosted coils. For this style of defrosting system the necessary valves and pipe work must be installed.

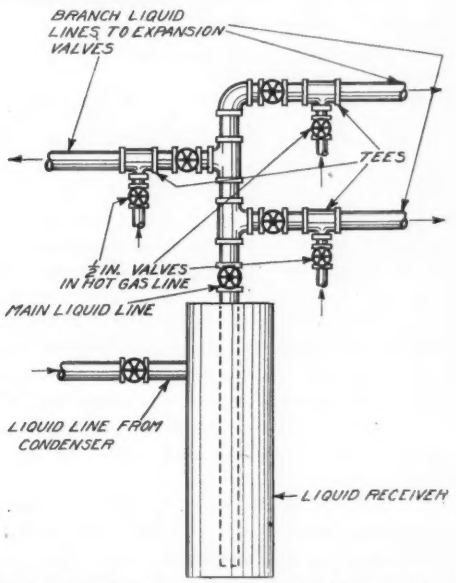


FIG. 4. ARRANGEMENT FOR FEEDING HOT GAS TO BRANCH LIQUID LINES

Where there are several branch liquid lines, each one supplying liquid for the coils of separate rooms, the hot gas can be fed into the liquid line at any convenient point between the liquid valve and the expansion valves. Then when defrosting is done, it is only necessary to shut off one branch liquid line and the suction valves of the coils fed from that branch and open the expansion valves wide and open the hot gas valve also.

There has been some argument as to the effect of introducing the hot gas into the cold liquid lines and coils; but during years of practice with this style of defrosting, I have never had any trouble.

The temperature of the discharge gas does not remain high long enough to be noticeable after it once enters the liquid line. Its heat is quickly taken up by the saturated vapor in the coils.

The discharge gas being dry and superheated, its introduction into the coil causes rapid superheating of the liquid laden vapor that is in the coil, and this superheating is what does the defrosting.

The temperature of a zero freezer will scarcely lose more than a few degrees during the short time it takes to clean the coils completely, and in cold rooms the frost will drop off dry and not cause much dampness.

Always, before any defrosting is done, provision must be made for the removal of the frost. When ceiling coils are being defrosted, some kind of covering should be spread over the produce that is in the room. When the space is narrow between the wall and wall coils, defrosting should be helped along by a man with a straightened out hoe or other handy tool. His duty will be to prevent the loosened frost from sticking and piling up.

In a large plant the installation of a real defrosting system will be a paying proposition. This will allow for any coil in the plant being freed of frost without interfering in any way with the other coils.

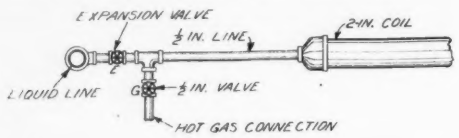


FIG. 5. CONNECTION FROM HOT GAS TO EXPANSION COIL

Following is a good and convenient plan. The hot gas from the discharge line can be introduced either at the inlet or outlet of the coil. First the connection must be made to the discharge line, and no better place can be decided on than the regular pump-out connections that are found on all ammonia compressors, Fig. 2. The pump-out lines are the cross connections between the suction and discharge lines close to the compressor. These cross connections are intended for use in pumping the ammonia out of the compressor when the compressor is to be opened up or when the rod is to be packed. By their proper handling the ammonia can be drawn from the condenser and stored in the evaporating coils.

If an ammonia compressor is not provided with pump-out connections, it should be so provided as soon as possible, for they are necessary.

Arrangement of Defrosting System

The original pump-out connections are provided with but one valve each; but for reasons which will appear later, two valves must be placed in one of them, one valve close to the discharge line and one close to the suction. Between these two valves a tee is placed, with a valve next to the side opening.

It will be found that pipe sizes of 1 or 1¼ in. will be best for all purposes, but if the cross connections at the compressor are ¾-in. they need not be changed; but have the side opening of the tee 1 in., Fig. 3.

Next, a 1 or 1¼-in. line is extended to all parts of the plant where defrosting of coils is desired.

Put a tee and valve on each coil, either next to the expansion valve, Fig. 4, or next to the suction valve. At the expansion valve is more convenient, as the tee can be placed in the ½-in. pipe that is between the expansion valve and the coil. A ½-in. tee and valve will do at this point, Fig. 5. All the coils are now connected to the line running from the compressor. The pipe work of this entire defrosting system should be properly insulated.

Now when a coil in any part of the plant is to be defrosted, the expansion and suction valves are closed and the valve G, Fig. 5, opened, also valves P O and D, Fig. 3, which allow the discharge gas to pass from the compressor to the coil. Allow the hot gas to enter the coil till the frost is entirely removed. This cannot always be done, as sometimes a coil has been allowed to become so ice coated that defrosting must be resorted to three or four times before a clean coil is the result; and as a rule, this partial defrosting several times is better than trying to do the whole job at once. The reason for this is that too much ammonia will store in the coil and other parts of the plant will be affected.

After a coil is clean, shut the pump-out valve P O, Fig. 3, which is between the hot gas defrosting line and the discharge line of the compressor.

Then to pump out the clean coil, open the other pump-out valve S, Fig. 3, that connects the defrosting line with the suction side of the compressor. Handle this valve carefully and do not open it wide enough to reduce the regular discharge temperature greatly.

A thermometer is almost a necessity in both suction and discharge lines at the compressor, but unfortunately few machines are so provided. If there is no thermometer the temperature must be judged by the hand.

If too much liquid comes from the coil, the discharge will get cold and the compressor will pound unless the flow of liquid is reduced.

A pressure gage is a convenient attachment to have in the cross connection. Then, when pumping out a coil, it is readily noticed when the pressure in the coil

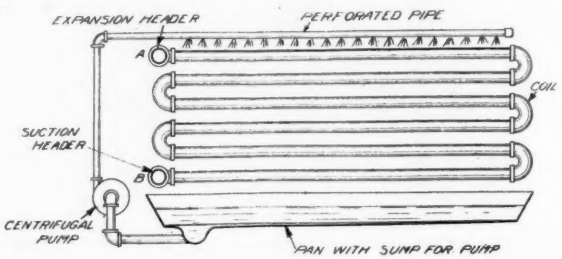


FIG. 6. BANK COIL WITH CONTINUOUS DEFROSTING SPRAY

is the same as that on the low pressure side of the system.

Defrosting System for Pump-out

When a plant is equipped with this style of complete defrosting system, it will be seen that the installation will also answer another purpose. It will be a pump-out system and so arranged and connected that any coil in the plant can be entirely pumped out without interference with any other coil. In case of a leak in a coil, that one coil can be shut off, pumped out, repaired and put back in service while all the rest of the plant is operated as usual.

When coils are defrosted with the discharge gas system, a great amount of the oil which is in all direct expansion coils will be pumped out with the ammonia. This oil will settle in the oil trap or receiver on the discharge line. Try the blowoff or drain valve on this oil trap after defrosting a few coils and the amount of oil taken from the system will pay for the trouble.

Do not neglect defrosting, but give this part of the plant operation careful attention.

Defrosting in Chill Rooms

In the hog and beef coolers of packing house plants defrosting can generally be taken care of without much trouble. As each cooler or chill room is provided with a number of coils, one or more of these can be shut off and the heat of the room allowed to melt the frost.

This method of keeping the direct expansion coils free of frost accumulation is also a great help in the chilling of the meat. When a cooler is filled with hot meat, two or three coils should first be turned on. The heat from the meat will cause these coils to frost quickly. After the steam-like vapor has settled on the few coils, the room will be clear and the air fairly dry. Then the frosted coils are shut off and the bare coils turned on. The coils which were first used will melt free of frost and the full effect of the rapid heat exchange through clean pipe will be available after the second set of coils are heavily frosted.

This alternative use of coils is also recommended where the brine circulating system is in use. The reason in both cases is the same, as heat will pass more readily to the brine or ammonia if there is no ice and frost to act as insulation.

Spraying Process

Some refrigerating plants are operated on the forced air or fan system. In this system the air is circulated around the direct expansion coils by means of a fan.

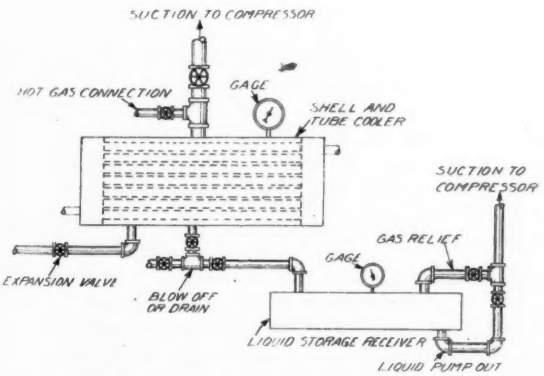


FIG. 7. ARRANGEMENT FOR DEFROSTING SHELL AND TUBE COOLER

The cooled air passes to the storage rooms by way of air shafts or ducts. The coils are in banks placed in a room called the bunker room.

These banks of coils are made up of coils built very close together, and one bank often consists of 15 or 20 coils each 12 pipes high. Ice and frost allowed to accumulate on such coils is very detrimental to good results.

The hot gas defrosting system can be used, but a continuous spraying of brine will be found much better. If the brine spray is to be used the coils are set in a pan such as is found under ammonia condensers. This pan is provided with a small sump in one corner, to which the brine will flow, Fig. 6.

Over each coil a perforated pipe is fastened the same as the water distributing pipe on the ammonia condenser. A small centrifugal pump is used, and the brine is circulated over the coils all the time that the coils are in use. The refrigerating effect of the entire system will be greatly increased by the installation of this style of defrosting system.

Shell and Tube Coolers

During the last few years the shell and tube brine cooler has come into general use in all classes of refrigerating plants. Although commonly known as brine coolers, this style of evaporator is found in plants where air circulation instead of the brine system is the practice. The shell and tube cooler is used just as the banks of coils are. It is very compact and the evaporating surface is large for the space required for the installation. A fan is used to circulate the air directly through the tubes, and then to the rooms being refrigerated.

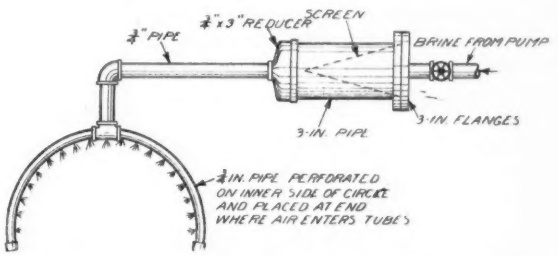

SCREEN
3"x3" REDUCER
3" PIPE
BRINE FROM PUMP
3-IN. FLANGES
3-IN. PIPE
¾ IN. PIPE PERFORATED ON INNER SIDE OF CIRCLE AND PLACED AT END WHERE AIR ENTERS TUBES

FIG. 8. DEVICE FOR CONTINUOUS DEFROSTING OF SHELL COOLER

Many ice cream plants have this system for the hardening rooms, as a temperature of several degrees below zero is easily maintained, and the circulating air makes the hardening of the ice cream quick and uniform.

At times the frost and ice proposition becomes serious, as the tubes will become choked and the air circulation greatly diminished; and with this condition existing, the cooler cannot evaporate its proper amount of ammonia to produce the tonnage required. As the air circulation slows down, the expansion valve will have to be closed somewhat to prevent the cooler from becoming too full of liquid and freezing back on the compressor.

The hot gas defrosting system can be used, but it is not just what is desired.

Hot gas cannot be introduced into the shell while the shell is partly full of liquid, as the pressure generated would most likely cause a rupture. Before the hot gas can be turned in, the liquid must be drained out. (Pumping the liquid out is too slow.)

To drain the shell, a suitable liquid receiver must be installed and connected up to hold this liquid while defrosting is done, Fig. 7. The feed or expansion valve and the suction valve are shut off and the blowoff is opened. The gas relief valve on the line between the liquid storage receiver and the suction of the compression is opened about a turn or a little less. Then the hot gas valve is opened a turn. The increased pressure on the shell will force the liquid into the receiver. This takes only a few minutes, and when the liquid is out of the shell, the blowoff line will warm up. Shut the blowoff

valve as soon as the liquid is out. The ice and frost on the shell and in the tubes will melt quickly.

Almost any ordinary size cooled (up to about 50-ton capacity) can be entirely defrosted in a half hour unless the tubes have been allowed to freeze up nearly solid. When the tubes do contain much solid ice, defrosting is greatly helped by pushing the ice out with a piece of pipe as it becomes melted loose.

During the time the cooler is being defrosted, the greater part of the liquid in the storage receiver can be pumped out and sent to the condenser. The pumping out is done through the gas relief line, only that the valve connecting to the bottom of the receiver is opened and the one at the top is closed, and the remainder can be pumped out while the cooler is being filled from the regular liquid receiver and condenser.

For both safety and convenience there should be a pressure gage on the shell cooler and on the liquid storage receiver. Do not, under any circumstances, draw the ammonia down into the storage receiver and then imprison it by closing all the valves. Such an act may cause a serious explosion.

Continuous Defrosting for Shell Cooler

For a continuous defrosting arrangement for a shell cooler having a fan for air circulation, a perforated pipe is placed so that a mist of brine is blown through the tubes, Fig. 8. To accomplish this the pipe is bent to form about two-thirds of a circle which will fit just inside the flange which extends out beyond the tube sheet. Another perforated pipe is fastened along the top of the shell, so that a small amount of brine will flow down and keep the shell from frosting. The perforations in the bent pipe should not be more than 1/32 in. in diameter and spaced about 2 in. apart.

A fine mesh screen must be placed in the brine line, so as to prevent the small performations clogging. The screen is made cone shaped, of size to fit in a 3-in. pipe, and is held in place by the open end being flanged over so that the rim fits like a gasket between the pair of flanges that form one end of the strainer chamber.

The brine for the defrosting can usually be taken from the discharge of the brine circulating pump and drained back to the pump suction. Or a small centrifugal pump can be used as for the coils in the bunker room.

Even with the continuous brine spray, the hot gas system is often required. If the brine should become weak or stop circulating, the tubes will freeze up and hot gas is the best way to clean them.

Blowing Out Coils in the Refrigerating Plant*

Steam vs. Air. Getting Out the Oil. Ammonia Explosions

IN REGARD to blowing out expansion coils, double-pipe condensers and absorbers, the question was asked whether anybody ever had trouble when he connected up air and steam on a header and blew out one coil at a time; whether there had been any explosive effect or any ill results to gaskets other than slight leaks that could be taken up by tightening the bolts.

In the discussion which followed, various experiences and ideas were advanced by a number of speakers, which threw light on the matter and on the proper way to blow out coils.

In one 25-T. plant that was to be overhauled the manager said, "I think our coils may be very dirty, and that may be the reason we cannot get tonnage out of the plant. I want you to find out and clean the coils thoroughly."

The engineer connected up the steam line to the ice tank expansion coil header and converted the ammonia compressor into an air compressor so as to get plenty of high-pressure air. He then blew out each coil separately with steam, followed as quickly as possible with a thorough air blowing, to remove all moisture. He got over 3 bbl. of oil out of the coils besides considerable water, and the difficulty, after starting up with the coils well cleaned, was to keep the brine temperature from getting too low. There was no trouble with explosion or leaks, but in a similar case, where steam was used, the joints in expansion coils having rubber gaskets, there was a good deal of fun with leaky joints when the plant was started up.

*From a discussion before the N. A. P. R. E.

Use Plenty of Air

Other speakers called attention to the fact that frequently, after blowing out with steam, the air supply is not sufficient to blow out the moisture thoroughly. The steam cuts out oil and dirt much better than the air, but air must be blown through afterward sufficiently long to clear out all moisture. The steam blowing should be continued until all oil is cut out and the pipes are hot.

One suggestion was that for double pipe condensers the inside pipes be taken out to give a better path for the steam and air. Another, that to get sufficient volume of air, a spare boiler be drained and used as an air receiver. A convenient form of blowers, see sketch, is a tee taking steam on one end and air on the other, with a valve to control the supply of each. The outlet is fitted with a piece of pipe formed to act as a blowing nozzle. It is a good plan after blowing out with the air to close the coil at the lower end and pump a vacuum on it. This will absorb all moisture in the coil or that may condense after the air blowing.

Blowing of coils is necessary because of the accumulation of oil, and one speaker advocated using a proper oil, keeping the oil trap and separator blower down and thus avoiding the blowing out of coils. He stated that he had operated many plants and had blown down coils only once in his life. Occasionally, on a dry expansion system, he would shut off all expansion coils, then open one at a time up wide for a short time, and thus send ammonia through at high velocity to blow out the oil.

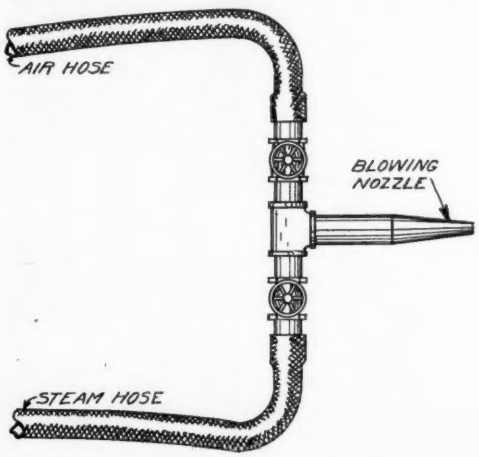
Others agreed that coils kept in proper condition need not be blown out, but the tendency is to pump in too much oil; the compressor passes it on, and the oil trap does not take it all out. Then oil gets into the coils and must be blown out to keep up capacity.

In one 125-T. plant it was possible by a few changes to get 140 T. a day. Oil was used to cool the compressors and to fill clearances. There were two suction lines coming back from four tanks, and on each line was an oil trap 18 in. diam. by 7 ft. high. About every two weeks those traps would fill with oil, some 35 gal., which would be drawn out and pumped back into the compressors. Yet the coils were not blown in the 7 yr. that the speaker was there, so the oil must have carried through the coils without accumulating, for the plant made as much ice the last day as the first.

Lye and Caustic Soda

One question was whether lye could not be pumped through the coils to cut out oil.

To this it was answered that the use of any caustic would tend to decompose the ammonia if any trace of



NOZZLE FOR STEAM AND AIR BLOWING

the caustic is left in the coils. Another engineer stated that he had used hot caustic on a plant that had been idle for 2 yr., and thought he got the coils cleaner than by any other method. He pumped a vacuum on the coils after cleaning and thus drew out all traces of the caustic solution before putting in ammonia.

Another objection raised to the use of lye or caustic soda solution was the likelihood of destroying all fibrous packing in the system, both at joints and in stuffing boxes. The caustic solution was not recommended except where coils had been idle for some time. After it is used, it should be followed up by blowing with steam thoroughly, then with air, and then by pumping a vacuum on the coils for 24 hr.

Explosions

Experiments made by one firm, lasting over a year, showed that a mixture of air and ammonia will explode only when the proportions are just right. No explosion could be gotten until the mixture was about 20 per cent ammonia, the passing of an electric spark would cause a slight explosion. At 22.5 per cent the explosion was violent, but at 25 per cent and above there was no explosion. It would seem, therefore, that the range of an explosive mixture is small, and the chief cause of explosions in an ammonia system where air is present are due to oil in the system.

It is therefore important that, in blowing the coils, the steam be left on long enough to clear out all oil. Then when the air is used, there is little chance of forming an explosive mixture.

The presence of water, however, tends to assist in decomposition of ammonia into nitrogen and hydrogen; impurities in the ammonia also assist the decomposition, as does carbonic acid, especially if the ammonia be in contact with two or more metals, so that a galvanic current can be set up. For this reason it is important that all moisture, carbonic acid or other foreign matter be entirely removed from the coils before putting in ammonia, so that there will be no chance for decomposing the ammonia, which might result in forming an explosive mixture.

Ammonia itself is not combustible and cannot explode except as it may be confined, and subjected to a temperature that will cause vapor to form rapidly and thus raise the pressure. This sometimes happens in drums or in closed receivers subjected to heat, hence the drums should be stored in a cool place, and receivers should never be closed up tight unless provision is made to keep them cool. This may be done by cracking a discharge valve, and allowing a small continuous evaporation which will cool the remaining liquid below the vaporizing temperature for the pressure carried.

Ammonia Compressor Lubrication*

Qualities of a Good Lubricant. How to Apply It. And Some Things Not to Do. By J. N. Pruitt

To perform its functions properly, a lubricating oil should have body sufficient to keep bearing surfaces apart; should reduce friction to a minimum; should remain fluid at the lowest temperatures to be met in service; should not decompose and form deposits that will gum up the machinery; should have no ingredients which can corrode or pit metal, and should have flash point high enough to insure against the presence of volatile constituents.

To avoid vaporizing too quickly under the high compression heat in an ammonia compressor cylinder, a lubricant must have a good flash, say, 325 deg. F., and as some oil in vapor form is likely to be carried into condenser pipes with the ammonia gas, the cold test should be low enough so that the lubricant will not solidify in the piping and coils—5 to 10 deg. F. If it is carried on through with the liquid ammonia, it can be taken out by an oil trap, placed ahead of the liquid receiver and at the lowest point in the expansion and condenser coils. Such a trap may be made of a piece of 4-in. piping, 2 ft. long, with a draw-off connection at the bottom.

If the lubricating oil gets into the condenser coils and stays there, it can be loosened by cutting off the water from one stand at a time, allowing the coil to become hot, so that the oil is thinned and will run off into the oil trap.

*From a paper and discussion before the N. A. P. R. E.

Oil carried over, and collecting in the condenser and expansion coils, is a source of lost capacity, and is frequently due to locating the oil separator too close to the compressor discharge, where the gases are hot and the oil mostly in vapor form. Placing the separator near the condenser gives time for the gases to cool somewhat before reaching it, so that the oil is partly condensed and is more readily separated.

All oil used for the compressor cylinder should be measured and a record kept. Any unusual increase in the amount fed should lead to an immediate investigation to prevent "filling" of the system.

As hot ammonia gas has a bad effect on stuffing box packing, a liberal supply of oil should be applied to the piston rod in the stuffing box to reduce the chance for overheating.

Discoloration in the ice is not always due to oil. Two cases were mentioned in the discussion, one where firebrick was used to fill an open heater in which there were no flow pans, and the mineral matter from the brick carried over into the ice; the other where rust from a fore cooler caused the trouble, which was remedied by painting the inside of the fore cooler.

Outside Header Superheater

EXPERIENCE in the design and manufacture of steam superheaters has indicated a number of essential points connected with their design, construction and operation. These may be summarized as follows: 1. Safety in operation. 2. Accessibility for inspection

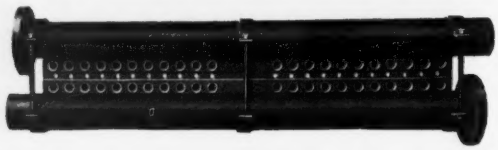


FIG. 1. SUPERHEATER HEADER SHOWING GROUND JOINTS FOR CONNECTION OF UNITS

and repairs. 3. Protection against overheating, insuring maximum life. 4. Maximum superheating efficiency. 5. Improved efficiency of the combined boiler and superheater. 6. Consideration of steam velocities and steam areas in order to provide minimum drop in steam pressure. 7. Uniformity of superheating, and ease of regulation. 8. Provision for expansion and contraction of all

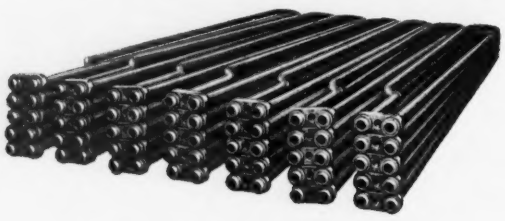


FIG. 2. SET OF SUPERHEATER UNITS

parts. 9. Provision for keeping units clean. 10 Minimum possibility for leaks. 11. Flexibility in adaptation to different design of boilers. These factors have been embodied, it is claimed in the outside header superheater.

This superheater comprises two headers, one acting as the distributor for the saturated steam and the other collecting superheated steam, and the necessary connecting units in which the superheating occurs.

Headers are made of steel, are located entirely outside the hot gas path, and in many designs, outside of the boiler proper. Thus the headers as well as the unit joints are accessible for inspection and repairs without entering the boiler setting. Safety valves conforming to the A.S.M.E. Code are located near the outlet, and provision is made for drainage and connection made for thermometer cups.

In most cases the headers are made with the outlet of the superheated steam header in a location opposite to that of the saturated steam header to provide an even distribution of the steam flow through all units. Where conditions require it, the saturated steam header is provided with several inlets.

Units are made of heavy, cold drawn seamless tubing of proper diameter to give correct steam areas. No

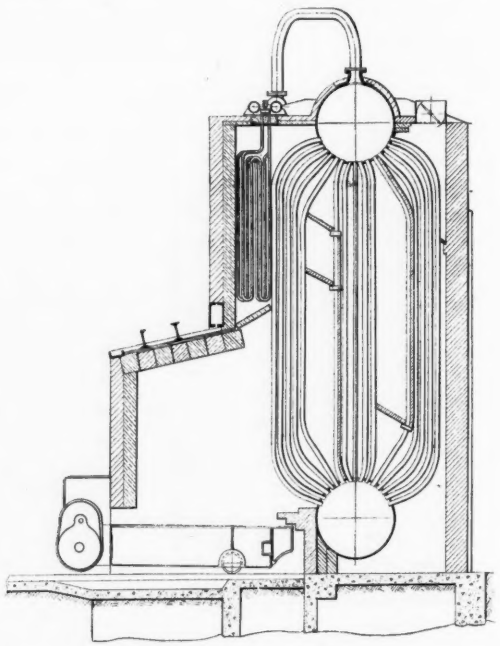


FIG. 3. TYPICAL ARRANGEMENT OF SUPERHEATER IN VERTICAL WATER TUBE BOILER

covering is provided, the smooth external surface offering minimum resistance to the flow of the gases and avoiding serious soot collections. Free expansion and contraction of all parts is claimed, due to the form of the unit. Figure 2 shows a set of units ready for connection to the header.

Due to the fact that the units are made of small diameter tubing, it is possible to obtain correct relations between steam areas and heating surfaces, it is claimed, and so distribute the cross-sectional area through the superheater as to obtain the most desirable steam velocity without the use of cores.

Between the units and the headers is a metal to metal joint to permit the easy removal of the units without special tools. Any unit can be disconnected without interference with the other units. Disconnecting a unit merely consists of loosening a clamp bolt.

This superheater is applicable to all types of boilers. Figure 3 shows a typical arrangement for a vertical water-tube boiler.

Industrial Use and Limitations of Gas Masks

DURING the last year the Bureau of Mines has received many inquiries regarding the use of army gas masks in the industries for protection against poisonous and irritating gases. These inquiries show a general belief on the part of the public that this type of mask will protect the wearer under all conditions against any gas whatsoever, even in absolutely irrespirable air, to the exclusion of the more cumbersome mine rescue breathing apparatus. This erroneous belief will no doubt be further confirmed by millions of discharged soldiers who have been trained in the use of the gas mask and have been taught that it gives them absolute protection against all gases used in warfare or likely to be used. These men do not realize that out in the open air of the battlefield the percentage of gas in the air can never be anywhere near as large as may occur in the confined spaces of a factory operation.

A mask may afford complete protection under outdoor conditions and break down at once when used indoors where a gas container has burst and filled the room with a greater concentration of gas. It must also be remembered that the absorbents in the army respirator, which filter out the poisonous gas, are specially designed for the gases used in warfare, and, as a matter of fact, do not protect against the more common industrial gases as, for example, illuminating, natural, producer and blast furnace gas.

The army gas mask never should be used in mines, because of the uncertainty there is of the kinds and amounts of gases in the atmosphere and liability of insufficient oxygen to support life.

Dust Respirators

Protection from dust and liquid mists is obtained by the use of a simple dust respirator, which removes these particles by means of a filter of moist sponge, cotton or wool pad, porous paper or even a very fine mesh metallic gauze. The respirator may enclose the mouth and nose only, or it may be combined with a face mask containing eye pieces if the eye must also be protected. The simple "pig snout" respirator containing a moist sponge has been on the market for years. It is very uncomfortable to wear, rather insufficient for removing fine dust and most workmen prefer to tie a large handkerchief over their nose and mouth. Some improvement has been made in recent years, but on the whole a really efficient and comfortable dust respirator that workmen will wear continuously is yet to be devised. On account of the urgent need of such a device for safeguarding the health of workmen in the mining and metallurgical industries, the Bureau of Mines has undertaken a study of dust respirators with a view to seeing that as satisfactory a model as possible is available to these industries.

Army Gas Mask

The army gas mask consists of a face piece of rubber and cloth fabric, containing eye pieces and connected by means of a flexible rubber tube to a canister containing charcoal and soda-lime for filtering out the poisonous gas from the inhaled air. The canister is supported in a knapsack slung from the neck.

The army gas mask is by no means the unusual protective appliance that it is popularly believed. It does *not* afford universal protection against all gases, nor can it ever be used safely in low oxygen atmospheres. It furnishes no oxygen to the wearer and can only remove comparatively small percentages of poisonous gas from inhaled air, usually less than 1 or 2 per cent. Higher percentages will immediately penetrate the canister and "gas" the wearer. The standard army gas mask will furnish protection against percentages not exceeding 2 per cent of the following gases in air: sulphur dioxide, hydrogen sulphide, chlorine, carbon bisulphide, nitrogen peroxide, anoline vapor, benzyl bromide, benzyl chloride, chloracetone, chlorpicrin, hydrogen chloride, phosgene, titanium tetrachloride and silicon tetrachloride.

It will be seen from the above that the field of usefulness of the army mask is confined to certain of the chemical industries, around smelters and roasters, where sulphur fumes are given off, and in the industries using chlorine and bleaching powder. The army canister also contains cotton filter pads which remove irritating and poisonous dusts, which increases its usefulness around smelters where sulphur and arsenic fumes must be removed.

The army mask furnishes no protection whatever against carbon monoxide. This is the poisonous constituent of blast furnace, producer and illuminating gases, and of mine gases after fires and explosions in coal mines. Carbon monoxide is also likely to be present in ordinary fire-fighting conditions met by fire departments. Moreover, in all of these cases there is likely to be a deficiency of oxygen. Therefore for adequate protection against these conditions the oxygen breathing apparatus must be used, and reliance on the army mask may be fatal.

The Bureau of Mines is working on a carbon monoxide mask and hopes to develop one that may be used in the future for low concentrations of this gas, but such a mask is not now available.

Ammonia is another gas that will penetrate the standard army canister. However, a special chemical may be placed in the army canister which will adapt it for use around refrigerating plants.

Oxygen Breathing Apparatus

The self-contained oxygen breathing apparatus can never be displaced by the gas mask for use in atmospheres deficient in oxygen. Such atmospheres are encountered in mine rescue work, in gas mains, blast furnace stoves, gasoline tanks, etc. Aside from the lack of oxygen, carbon monoxide is also present, for protection against which the army mask is useless.

The oxygen breathing apparatus must also be used instead of the army gas mask wherever there are large quantities of irrespirable or poisonous gases, as, for example, in entering a gasoline tank containing some residual liquid or similar tanks, towers and other closed spaces. The concentration of vapors produced by volatile liquids in closed containers is too high to be entirely removed by gas mask absorbents. The only recourse in such case is a self-contained appliance in which the wearer does not breathe any of the irrespirable atmosphere.

Notes on Boiler Repairs

IT WAS with considerable interest that I some time ago carefully examined the volume of the Power Plant Engineering Library entitled Engine and Boiler Room Lore. This was prepared, I believe, by W. E. Dixon,

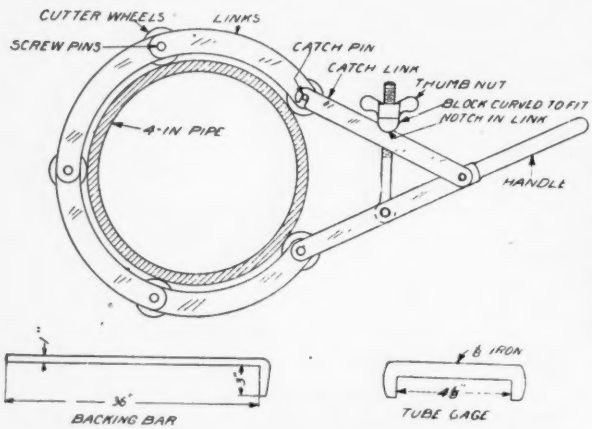


FIG. 1. THE FIVE-WHEEL TUBE CUTTER

and while, as a whole, the little book contains some very excellent material, I discovered a number of points upon which I do not quite agree with Mr. Dixon.

On page 27, he tells how to cut out a tube, warning

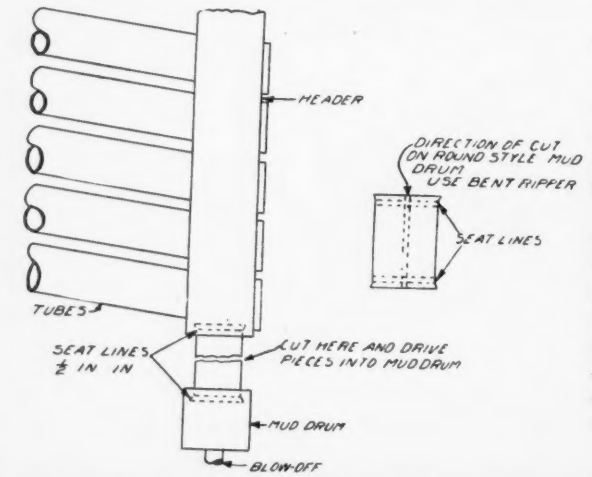


FIG. 2. SHOWING METHOD TO EMPLOY IN REMOVING NIPPLE

the reader to be careful not to cut the seats. Accidents will, however, occur, and I might say that if a seat is slightly cut, a half-round file, properly used, will soon remedy this; and, if it is cut all the way through, let the man find a nice heavy piece of copper which can be easily filed to fit the slot, the copper being left slightly large so that when expanded it will fill up the entire space. This will remedy the trouble nicely. In cutting out tubes of water tube boilers of the B. & W. type, a man can save himself considerable trouble if he will secure a five-wheel cutter of the kind shown in Fig. 1. He may be lucky enough to have one, or know a neighboring engineer who has one. This pertains to top or bottom tubes and especially those badly blistered, split, or corroded and hard to draw through the cap hole.

By going into the firebox and soot chamber in the rear, and making two cuts, or into the two upper chambers for top or bottom tubes as the case may be, he can save himself a lot of trouble. Naturally, the repair man may get a lot of dirt down his neck; but he is more than repaid by the time and labor saved. In boilers having what is known as a Webster furnace, that is, where the baffle is ahead of the bridge wall, a tube need only be cut once near the bridge wall in the firebox, and the

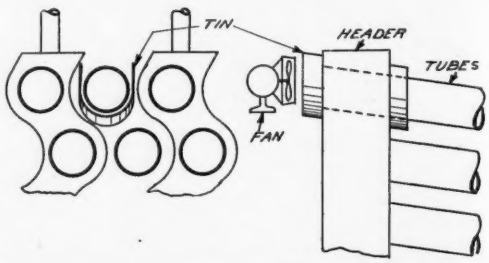


FIG. 3. ARRANGEMENT OF FAN AND CHARCOAL PAN FOR HEATING TUBE

front ripped by the seat. It can then be drawn down into the firebox and the front half taken out, leaving enough room to draw the back half forward into the firebox, and out through the furnace doors.

In his talk on expanding, Mr. Dixon gives directions for expanding and belling or flaring the tube afterward, and tells his readers to use tapered rollers. It may be that the engineer or man in question may not have a tapered roller in his tool stock; if not, he can accomplish the same result by holding the expander so that the roller extends ¼ in. outside the tube. Then tap the mandrel gently, give it a few turns, and repeat this tapping until it is sufficiently belled.

On the old type of B. & W. boiler, there is invariably a round cast-iron mud drum, while on the later types the square steel mud drum is used. On the first mentioned (round mud drum), I generally split the nipple the entire length, using a bent ripper. By first driving a hole about the center of the nipple, I can get an approximate location of the two seats. Then I start from the

top and take off a little at a time as you would cut a key way on a shaft. Afterward, the nipple can be bent away from the seats by going into the soot chamber, placing your ripper flat against the nipple, and hitting it with your hammer. After it is loose, it can easily be driven down into the mud drum. This is not a job I would advise any man not familiar with it, to attempt, for it is more a matter of instinct and feel than anything else to know when you have cut enough and not keep going till you cut through the seats. In a square mud drum, the nipple can be cut in two, and driven out the seats.

Concerning his tube forge, he must remember that there are some places where no air machines are available. In such cases, if a piece of tin or sheet iron about 18 in. square is procured and bent so that it fits around the tube and extends along the side a bit, this work can be nicely done. Fill the pan all around the tube with charcoal, covering it well, and get a fan of the common office or house variety. Place this in front of the tube to be heated, light the charcoal, and start the fan and you will discover it makes a good blast forge. If no fan can be secured, get something large enough to block the opening on the bottom of the tube to be heated (a piece of board will do and a piece of tin can be bent to hook and hold up on the top); then open your damper a little and the suction of the stack will provide the necessary draft. This is slower than the first mentioned method, but handy in a pinch.

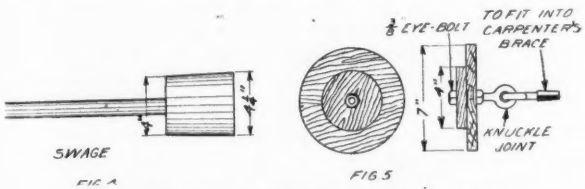


FIG. 4. SWAGE FOR BRINGING IN END OF TUBE
FIG. 5. CAP FACE CLEANER AND METHOD OF APPLICATION

His swage for bringing in the end of the tube is different from the kind I use, first, in being bell shaped as he states; second, in the diameter of the inner part, being the same as the inside of the tube. The kind used by the B. & W. Co. is as follows: The outside diameter of the swage is the same as that of the tube cap, and tapers from 4¼ in. on the end, to 4 in. on the inside, which is the outside diameter of the tube when new. The reason for the swage being made so is that the tubes often are sprung so that when the old header is taken off they rest tightly against the neighboring header, and it makes it difficult to get the swage on when they are red hot, so much so that I wonder how I would get the swage Mr. Dixon mentions, on, before I would lose the heat.

Regarding the steel header, which he mentions and says that if they have to be taken off the tubes must be sacrificed, I must deny this; for, as it is done to-day, no tubes need be lost any more than on the cast-iron header.

The tubes are forced in by the use of a crimping bar, and a strong pulling apparatus put on top and bottom which draws the header off with a little hitting on the back, after which the same method is followed as in the cast-iron style of header.

Engineers who operate boilers with ground faced caps can save themselves much labor when cleaning them by the use of two circular blocks, one 4 in. in diameter, the other about 7 in. in diameter. Drill a hole through the center of each and secure with a bolt with a nut to tighten. With the emery cloth between these two members, make a knuckle joint by the use of two eyelets as shown. This can then be placed in an ordinary brace, and a few turns will make a nice smooth surface on the header face.

E. J. DUFF.

Screwed vs. Flanged Blowoff Valves

IN POWER PLANT ENGINEERING, April 1, page 320, I notice that several recommendations have been made by manufacturers in regard to standardizing blowoff valves, and I regret to say that the use of screwed blowoff valves on boilers should be avoided for the following reasons, based on practical experience in power plants:

Screwed fittings are a little cheaper than flanged, even though the flanges do not need gaskets and machine bolts, but this slight difference in price should not be considered, as we have to look out for safety in the first place.

A boiler blowoff valve is generally connected very close to the floor and at the rear end of the boiler; in most cases the space is dark, dirty and narrow, only large enough for one man to operate the valve.

In an up-to-date plant, which is under competent supervision, the boiler will be cleaned once a month; but, in many cases, this cleaning has to be done in a rush, and as the men are distributed all over the boiler, inside as well as outside, the one who has charge of cleaning the blowoff valve is in the way of everybody else and will try to leave his place as soon as possible.

To repair, especially to grind a valve, under such conditions is not a pleasant task, and you cannot expect the man to feel much interest in this kind of work. The result is that the blowoff valve is sometimes in a worse condition than it was before overhauling.

Assuming that the stream of a leaky blowoff valve is about ⅛ in. (which is not exceptional), then the loss per year for that one valve will be about $300. From this it is readily seen that in power plants with 10 or more boilers, the loss of money runs considerably higher.

In using flanged fittings, the man who has to overhaul the valve can disconnect the flange and take the valve apart on a clean bench and look over each part carefully.

He is also in a position to inspect the stud-bolts of the guard on top of the valve. This is essential because it has happened many times that while blowing off the boilers one of the stud-bolts has broken, thus injuring the operator.

Another advantage of the flanged blowoff valve is that a thorough inspection and cleaning can be made of the nipple between the valve and boiler. If the valve is removed, which is more easily done with a flanged than in a screwed valve, the way to the boiler or mud-drum is clear, and the sediment can readily be taken out. If a blowoff stopcock is used, the boiler cleaner tries to clean the nipple by running a piece of wire through the body of the valve, resulting in damaging that part.

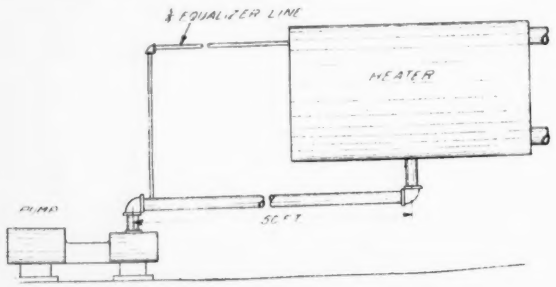
The operating engineer will admit that a valve or stop-cock cannot be ground correctly if there is not enough light to see what is done, and because the only way to have a valve or stop-cock tight is to grind it until

it fits perfectly, sufficient light must be admitted to enable this work to be done.

I would call your attention to these facts, which are based on many years of practical experience with blowoff valves. F. C. HEYLMAN.

Curing Difficulty of Pumping Hot Water

IN ONE PLANT with which the writer was connected, we had installed a horizontal open feed heater which was placed in the engine room, while the feed pumps were located in the boiler room about 50 ft. distant. While the arrangement worked all right for some time, a change in operating conditions which increased the supply of exhaust available for feed water heating boosted the feed temperature from 195 to 212 deg. F., when trouble began to be encountered because of pounding in the pump. The pump and the heater were almost on the same level with little effective working head and we concluded that the trouble was due to the limited flow to the pump, which caused some of the hot water to flash into steam when the pump plungers moved and when a solid body of water did not follow it. We were about to increase the pump supply line from 6 to 8 in. when we decided to try the experiment, as shown in the sketch,



BY EMPLOYMENT OF THE ¾-IN. EQUALIZER LINE, NO FURTHER TROUBLE WAS ENCOUNTERED

of running a ¾-in. equalizing pipe from the heater over to the pump supply line to vent off any air or steam which might be trapped in the line and also equalize the pressure. We put in this vent connection and were pleased to see that it completely cured the trouble, thus saving the expense of tearing out the 6-in. line and replacing it with one of larger size.

M. A. SALLER.

Disadvantages of Rapid Combustion

IN THE Apr. 15 issue, I notice W. H. Wakeman's comments on the above topic. I don't know what the capacity of Mr. Wakeman's plant is; but if 5 lb. of coal per square foot per hour is the most economical point at which he can operate his fires, something is materially wrong, I should judge, with the plant or the management. It is no uncommon thing for a plant of modern equipment to burn 30 lb. or more per square foot of grate and obtain a better evaporation than he mentions.

The best illustration of the slow and rapid methods of combustion may be to compare the furnace of a boiler with a Bunsen burner. If air is shut off the burner, the heat is immediately diminished but the same amount of gas is used.

Likewise a smoldering fire consumes the fuel without making much heat.

A fire brick can be obtained that will stand a working temperature of 2800 to 3000 deg. F., and if the brick is laid properly with the proper high temperature cement, the fire box will stand.

This is not theory but practice. The manager does not care whether the evaporation is 9.31 or 9.33 as long as the coal burned is less per week.

We have experimented at different times and found that when we can safely cut out a boiler, the water consumption and coal consumption are both less.

We have an excellent flow meter on the feed line and the coal is weighed by a modern traveling scale; yet, as I have stated, when a boiler is cut out the water consumption drops with the coal. To-day our average coal consumption was 22 lb. per sq. ft. of grate per hour, each boiler fire box containing something like 150 sq. ft. and the evaporation was astride the fence at 10.

It was possible to cut in another unit and reduce the rate of combustion to 18 lb. per sq. ft., but it would cost an extra 10 T. of coal to do it.

If we burned only 10 lb. of coal per sq. ft. of grate surface, the premises would not be large enough for the boiler plant alone.

A common horizontal return tubular boiler of 6 ft. diameter and 20 ft. in length will ordinarily develop 150 hp. without overworking and the grate will be 5½ by 6 ft. or 6 by 6 ft.

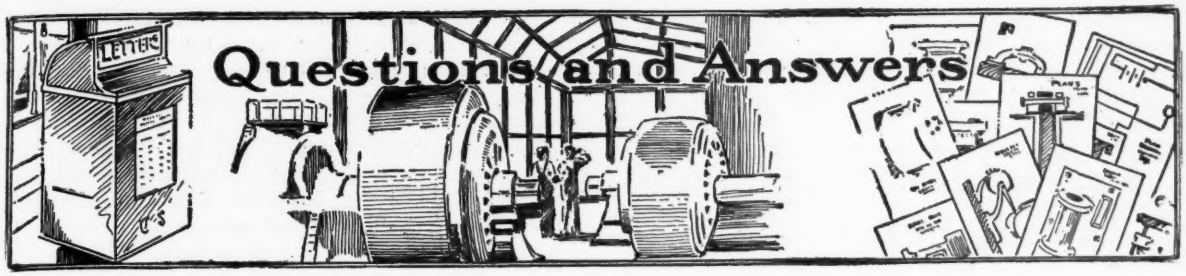
If the coal is of first quality, 3 lb. will generate a horsepower-hour approximately and 150×3÷36 will equal the amount to be burned per sq. ft. of grate or 12½ lb. per hr. I have developed 225 hp. per boiler of 6 by 18 ft. dimensions and burned over 20 lb. per hr. per sq. ft. of grate and made an evaporation by absolute weight, (not meter) of over ten to one.

It makes all the difference in the world how boilers are fired, as to the efficiency obtained; but when we talk of 5 lb. per hr. it is absolutely out of the firing question.

Our banked fires burn faster than that! I believe that for real efficiency when you are burning coal at a high rate of combustion the air supply should be sufficient to keep the fire box balanced.

Perhaps when Mr. Wakeman opens the uptake-dampers sufficiently really to burn the coal, a large amount of air is drawn over the fires which is not an aid to good economy and maybe a turbo blower in the ash pits would solve the riddle. TOM THUMB.

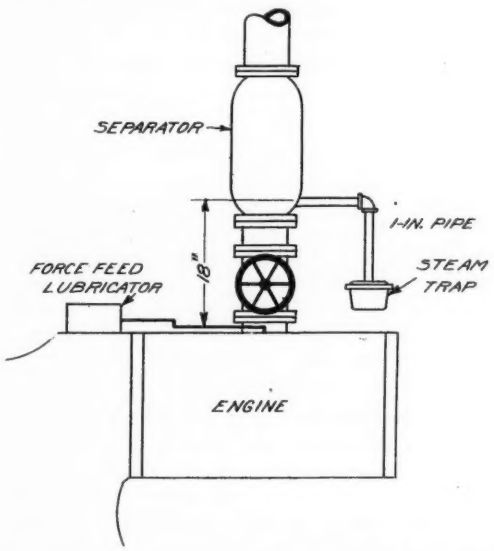
IT IS FELT in England that the combined effect of the recent prohibition of gold exports from that country to all destinations and of the unpegging of sterling exchange will bring about American investment in foreign securities. British purchases in the United States cannot be paid for in gold and it will be a long time before British exports will rise to the point necessary to pay for imports. A way out is through private credits from the United States. The American Chamber of Commerce in London reports that British business men are watching with interest U. S. government action to encourage American investments in foreign securities by gathering extensive information on credit conditions in other countries for the use of prospective purchasers of private securities.



A Cylinder Lubrication Trouble

I AM IN CHARGE of a Lycoming engine operating at a speed of 300 r.p.m under a steam pressure of 110 lb. The throttle valve, separator, attached drain and trap and the cylinder oil piping are connected in the manner indicated in the accompanying illustration.

This equipment is causing me considerable trouble in that the cylinder oil instead of going into the cylinder seems to enter the separator and from there passes out into the trap.



ARRANGEMENT OF PIPING OF ENGINE IN WHICH CYLINDER OIL PASSES OUT THROUGH TRAP

Will some of the readers of Power Plant Engineering kindly give me their opinion of the probable cause of this trouble and the manner in which it may be remedied? E. C. F.

How Can This Vibration Be Prevented?

WE HAVE two 72-in. by 18-ft. horizontal return tubular boilers suspended on I beams in a moving setting that takes spells vibrating. Could any of the readers of Power Plant Engineering offer a reason for this and give suggestions how to remedy it? J. H. P.

Why the Peculiar Pump Performance?

FROM THE LETTER of C. C. H., page 340, of the April 1 issue, I judge he is referring to a single cylinder pump fitted with a piston valve having an auxiliary valve.

C. C. H. will probably find the auxiliary valve stem worn spool shaped where it passes through the stuffing box, so that when the rocker arm shoves the stem into the steam chest, the high steam pressure, aided by too much oil and loose packing, forces the stem out again before the pump has a chance to complete its stroke, thereby rapidly reversing the pump. This does not occur with no load, as the steam pressure is too low to cause the pump to reverse without the aid of the rocker arm.

A new valve stem and some good packing with a minimum amount of lubricant should remedy the trouble. J. B. J.

Answers to Examination Questions

JUST A few words on the examination questions beginning on page 381, Apr. 15 issue.

6. If it is a common running condition that a vacuum obtains in receiver, use a vacuum trap, which will discharge the condensate even though a partial vacuum is present.

8. There would be a decided objection to changing the piston rod in an old engine.

It is no uncommon thing to find a shoulder in the cylinder if the engine has been running for some years with the clearance unbalanced.

As to turning the rod around a number of turns, that is most decidedly out of the question.

Just think of the pitch of thread on a rod and the original clearance of the engine and then turn it a few turns for luck!

19. If the suction valves connecting the dry air pump to the condenser, were ordinary spring actuated poppet valves, the vacuum on both sides would balance and the weight of valve and pressure of spring would prohibit a high vacuum.

The valves are mechanically operated to remove this objection and to get the last tenth of an inch possible.

33. If it is desired to key an engine and know absolutely which pin needs keying, the engine should be placed on dead-center and the starting bar operated so that the piston is first pushed forward and then backward. While one man operates the valves, another observes which pin is in need of keying. If a vertical engine, it is only necessary to open and shut throttle to lift piston if engine is placed on lower center.

If help is scarce and the plant only affords one man, it isn't so necessary to have the engine run quietly as only one set of ears will have to suffer.

Theoretically the diameter of crankpin should be more at the point mentioned; that is, 45 deg. ahead of center, as no wear should take place at this point. In

practice, however, the writer has seen but one crankpin that showed perceptible wear.

If the wristpin is planed sufficiently on both sides to let boxes clear, no wear will bother the joint if proper lubrication is maintained. TOM THUMB.

Remedy for Cylinder Lubrication Trouble

I WOULD SUGGEST that H. M. S. examine his piston rings, and no doubt he will find them to have a knife edge which scrapes the oil off before it gets to the rings. By taking the edge off with a small flat file he will overcome his trouble. Would also recommend running an oil pipe into the center of steam line, capping the end and drilling a number of small holes with a ⅛-in. drill. This will atomize the oil with the steam and reduce consumption.

I also advise use of a dry graphite feeder and feed a very small amount of graphite. (Too much is worse than none.) In a little while this will form a veneer on the cylinder wall and produce a high polish, which will cut down oil a little more and also reduce heat radiation. He should get good results by using an oil with about 6 or 8 per cent compound of pure acidless tallow fat. Would like to ask H. M. S. how long these engines have been in service and if he has a steam separator connected just above the throttle. If he has he should connect his oil pipe below the separator. If he tries this I should like to hear of results through the columns of Power Plant Engineering, for there is where we get our help. F. V. BROADAWAY.

HAS H. M. S. ever given thought to superheat? That superheat in any quantity tends to break down the finest grades of cylinder oil made is a well-established fact. Has he ever given thought to the possible tendency of his steam to carry a little superheat? No great amount, but just enough to destroy the lubricating quality of the oil used. Therein may lie his trouble, and surely it is not without remedy.

If lubrication, with superheat, is to be accomplished, there remains but one way to do it effectively, and that is through the judicious use of chemically pure cylinder lubricating graphite. Whether your steam is wet, dry or superheated, in graphite you will find a possible solution for your cylinder and valve troubles. Superheat cannot break it down and water will not affect its lubricating qualities. To predict a complete cessation of all your troubles, even with the use of graphite, is beyond me; but, judging from past experiments and tests made with this lubricant, which I have conducted and therefore know whereof I speak, you could save yourself much worry and work by at least giving graphite a trial.

Equip your smallest engine with a suitable oil and graphite pump and order a quantity of graphite and oil mixture from some reliable firm. Be sure to order the best cylinder lubricating graphite obtainable. If you prefer to mix the compound yourself, to every gallon of oil you use add 1 1/5 oz. of graphite, and *stir it well.* Most graphite and oil pumps on the market are provided with a strainer, incorporated in the pump, through which to pour the mixture when filling the container and also fitted with an agitating unit of some pattern by which the graphite is kept in constant suspension. This latter item is one of the secrets of efficient graphite lubrication, for without complete suspension the best results cannot be obtained.

The discharge from the pump can be led into the steam pipe, the throttle or directly to the steam valves, and as for regulating the flow of the mixture to the engine, that can be left to the judgment of the engineer in charge. It is a simple matter to decide whether an engine is laboring or running smoothly by listening to the valve action; but, as a positive test, pull off the cylinder head some Sunday and see for yourself if the graphite has filled all imperfections in the cylinder and whether you now have a smooth, shiny surface for the piston to perform its work over. This is what you should find after a week or two of graphite lubrication, and if such is the case, you will be certain that you are using enough graphite. Then and then only can you begin to cut down the amount fed to the engine, and also the amount used in the mixture until you are satisfied that you are obtaining sufficient and proper lubrication.

Following is a table showing the friction losses of engines with the use of good, suitable lubricating oil. These figures are conservative and are compiled from recent tests:

Normal Engine Rating	Total Friction Loss	Cylinder and Valve Friction Loss
250 hp.	25 hp.	6¼ hp.
500 hp.	50 hp	12½ hp.
1000 hp.	100 hp.	25 hp.

By using a graphite and oil mixture as a lubricant, in place of the oil, you insure, besides a saving in lubricants, a better running engine capable of doing more and better work. The figures below will show the saving made in terms of horsepower, by bringing about through the use of graphite a 30, 40 or 50 per cent reduction of friction loss.

Normal Engine Rating	30 Per Cent Reduction	40 Per Cent Reduction	50 Per Cent Reduction
250 hp.	1⅛ hp.	2½ hp.	3⅛ hp.
500 hp.	3¾ hp.	5 hp.	6¼ hp.
1000 hp.	7½ hp.	10 hp.	12½ hp.

The above saving of course applies only to the cylinder and valves.

Therefore, if this saving in horsepower and consequently, coal, means anything to your employers, they should be willing to give this means of lubrication a fair and impartial trial. Care should be exercised to prevent the use of more graphite than the cylinder actually needs for in this manner you will practice a waste. If your employers will stand for a trial of graphite, go to it and at some future date slip a few lines into these columns and tell us how you make out. Yours for less worry. G. R. APHITE.

THE CYLINDER lubrication problem in the April 15 issue interests me. Perhaps the following may interest "H. M. S." as well.

He has not given enough data to analyze and diagnose the case. It is necessary to know just what load an engine is carrying for the greater part of the time, in order to decide as to the kind of oil to use. Load determines the volume and velocity of steam flowing into the cylinder, and the atomization of the oil in them

depends somewhat upon volume and velocity of flow of steam.

Then, it may be necessary to use an entirely different bodied oil in the low-pressure cylinder, than may be used in the high-pressure cylinder. Judging from what "H. M. S." states in his letter, however, I am of the opinion that he has been using an oil too heavy for his engine. He speaks of a "nozzle," which may or may not mean an atomizer. His engine may be under-loaded, and if so, the oil should be introduced further back from the throttle valve, say 10 ft. instead of 1 ft. If the load is light he will undoubtedly require a light body cylinder oil, mineral stock, for his high pressure cylinder, and a compounded cylinder oil also of light body, for the low-pressure cylinder. Each cylinder should have its separate lubricator, and its own atomizer. There should be no serious difficulty in solving this problem, when all the facts and conditions are known, from which an analysis can be made. Less oil should be used than that quoted by the correspondent, and the internal parts should be properly lubricated, if the points to which I have referred are looked into, and an attempt made to put the ideas into practice.

It will be interesting to learn further, just what "H. M. S." does, and the results attained.

CHARLES J. MASON.

Gasoline Engine Questions and Answers

PLEASE ANSWER the following questions: How many calories of heat are developed in one explosion in a gasoline engine?

2. What per cent of this heat passes out through the outlet valve?

3. How much does one c.c. of gasoline expand upon combustion. J. F. McL.

ANSWERS

HOW MUCH heat is liberated by the explosion in a gasoline engine is dependent upon the ratio of air to gasoline employed, and the quantity of such mixture admitted to the cylinder.

If we represent the volume of the charge after it has been drawn into the cylinder by Va, and the volume of the charge at atmospheric pressure by Vo, and assume "a" to be the air required per cubic foot of gas, and x the proportion of actual air to theoretical air, so that $(x-1)$ will be the percentage excess air, then the volume of cold mixture per cubic foot of gas will be $(xa+1)$, and the volume after it is drawn into the cylinder will be

$$\frac{Va}{Vo}(xa+1)$$

If H is the heating value per cubic foot of gas under standard conditions, the heating value of the mixture after it has been drawn into the cylinder will be:

$$H \div \left[\frac{Va}{Vo}(xa+1)\right]$$

2. The percentage of total heat delivered to the engine contained in the exhaust varies considerably according to the design and the operation of the particular type of unit. Results of tests conducted on a 300-hp. gasoline engine which the writer has before him indicate an exhaust loss of 24.1 per cent with the engine carrying 197 hp., 23.9 per cent when carrying 294 hp. and 24.8 per cent under a load of 335 hp.

The theoretical quantity of heat rejected may be determined by the following formula:

$$H_r = W\ C_v\ (T_t - T_a)$$

Where Hr is the heat in B.t.u. rejected at exhaust, W is the weight of gases contained in the cylinder; C_v is specific heat at constant volume; T_t is absolute terminal temperature, and T_a is absolute temperature of the atmosphere.

3. Unless the spark is considerably advanced, combustion in a gasoline engine is a case of combustion at constant volume.

Operating Jet Condensers

PLEASE ADVISE the method of starting and operating the LeBlanc low-level motor-driven condenser. J. L.

A. There are two general methods of starting a LeBlanc jet condenser. The first method is forced injection. The unit is first started non-condensing, allowing the steam to escape to the atmosphere through an atmospheric relief opening provided between the condenser and the prime mover. By means of a pump or static head water is forced into the jet condenser at the same time starting the condenser pumps. The unit will then automatically go to condensing operation, the atmospheric relief valve provided on the opening, closing when the pressure in the condenser drops below atmospheric. A gate valve in the injection line regulates the water in the condensers, as indicated in the gage glass attached to the side of the condenser.

The second method is by a priming ejector. A gate valve with a back outlet is placed between the condenser and the prime mover. As before, the unit is started non-condensing, but the gate valve is closed. Before starting up the unit, however, the steam primer on the air pump is turned on, and the pumps started. The primer creates a partial vacuum in the condenser which lifts the water into the LeBlanc air pump. As soon as the air pump becomes operative the primer is shut off and the LeBlanc air pump quickly evacuates the condenser, lifting the condensing water into the condenser by virtue of the vacuum. As soon as the vacuum is established the prime mover is started and the gate valve opened so as to admit steam to the condenser. R. R. DAVIS.

Modulus of Elasticity

KINDLY EXPLAIN the meaning of the term "modulus of elasticity." W. A. U.

A. Coefficient or Modulus of Elasticity is a term expressing the relation between the amount of extension or compression of a material, and the load producing that extension or compression. It is defined as the load per unit of section divided by the extension per unit of length.

Let P be the applied load, k the sectional area of the piece, L the length of the part extended, y the amount of extension and E the coefficient of elasticity. Then P divided by k is the load per unit of section; y divided by L is the elongation of a unit length.

$$\text{Then } E = \frac{P}{k} \div \frac{y}{L} = \frac{PL}{ky}$$

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Summer-Months' Service

In order to realize the greatest degree of economy both in the use of fuel and man-power the government during the months of our participation in the war advocated the shutting down of isolated power plants and the purchase of central station service wherever and whenever conditions warranted doing so. That such a policy should be followed goes without denial, but that such a policy should be followed regardless of conditions under which a particular plant may of necessity have to operate is an insinuation that all isolated plants are a source of waste of fuel and that only by the utilization of central station service may this be reduced to a minimum. This, as the majority of engineers well know, is not true.

Use of exhaust steam is the determining factor. Where exhaust steam is employed only for the heating of buildings during the winter and otherwise allowed to escape to the atmosphere the substitution of central station service throughout the non-heating months will without doubt prove economical. In few plants, however, is this mode of operation in use, for whether the plant in question be serving a factory, a hotel, a hospital or even an office building a demand for heat for some service or other exists and while it may be contended that such demand may be considerably less in summer than in winter the fact remains that the demand for electric energy, especially lighting, is also considerably less in summer than in winter. The ratio between the demand for exhaust steam and that for the operation of the engines and turbines therefore tends to remain fairly constant and as the prime mover will abstract but from 3 to 12 per cent of the heat of the steam it is but this amount of the total coal which can be saved.

Advocates of central station service contend, and rightly so in many instances, that a privately operated plant may require 8 lb. of coal for each kilowatt hour of electric energy produced while they can, let us say, produce a kilowatt hour on 2½ lb. If such is the case and assuming that 10 per cent of the coal is saved at the isolated plant by the shutting down of the engines the actual saving would be 3.2 times 10 or 32 per cent. In other words the isolated plant would have a consumption of 90 per cent of the amount used with the engines in operation while the central station would consume 68 per cent of that amount to produce the necessary amount of power thereby necessitating a total consumption of 90 plus 68 or 158 per cent of that previously required by the isolated plant.

If, on the other hand as in some few instances all of the exhaust steam is passed to the atmosphere then the actual saving in coal due to the employment of central station service will be in the ratio of the coal used per kilowatt hour by the two plants. Where as cited above, the central station requires 2½ lb. and the isolated plant 8 lb., the ratio of saving in favor of the former would be at 1 to 3.2.

As a rule, due to load conditions and the quantity of steam required for heating or other purposes more or less exhaust is or must be allowed to escape to the atmosphere and where such conditions prevail a critical point exists where either the purchase of electric energy or

the operation of the isolated plant will prove the more economical.

Equal consumption obtains when the proportion of total coal required for heating alone equals one minus the fraction representing the ratio of the kilowatt hour coal consumptions of the isolated plant to that of the central station. If, for example, the central station has a coal rate of 3 lb. and the isolated plant 9 lb. the critical point is reached when 1 minus 3/9 or ⅔ of the coal is required for heating. Anything in excess of this will throw the balance in favor of the central station; anything less than this in favor of the isolated plant.

It is thus obvious that while in some instances the purchase of central station energy may prove desirable in the great majority of cases, this is not so, and it is therefore not out of place at this time to sound a note of warning to those confronted by this serious question, to make a careful study of conditions existing at their plants. With the assistance of reliable metering devices the amount of exhaust steam usefully employed may be readily determined and with this information it is quite possible to refute the glaring statements and promises of such scheming central station agents, as may put immediate contracts ahead of engineering facts.

Mixed Fuels

Mixed coals for power plants have been given considerable study in some localities where price conditions seemed to indicate economy, and with properly designed furnaces good results have been secured, the idea being, of course, to get the greatest amount of heat for the money so that experiments have been made principally in localities where a low grade fuel can be secured at a low price while higher grades are proportionately considerably higher in price based on heat value. A mixture of low grade anthracite and bituminous coal is the common plan where mixed coal is used. As the anthracite culm cannot be burned alone, this scheme is to be commended as a method of conserving the resources of the country.

More recent experiments have been made in the use of fuel oil and coal simultaneously in the same furnace. This undoubtedly is an outcome of the practice in some plants of shifting from coal to oil when price conditions justified the change one way or the other. As reported by Mr. Meredith in this issue, burning the oil and coal at the same time permits the use of a lower grade of coal than when coal is used alone. This scheme makes the mechanical handling of the stokers simple, as the fluctuation may be taken care of automatically by the oil burner.

Another method of burning oil and coal together has been developed by the U. S. Submarine Defense Association. In this method, what is termed colloidal fuel, consisting principally of pulverized coal and fuel oil, is used and atomized in an ordinary fuel oil burner. The most difficult problem was to keep the coal from settling out of the oil and this has been accomplished by the use of a paste-like greasy substance, called fixateur. With a small percentage of fixateur added to the oil a stable liquid is obtained by mixing 45 per cent oil, 20 per cent tar and 35 per cent pulverized coal. Thus half the oil is replaced and a fuel of only slightly less heat value is obtained. By the use of waste products of mines as the solid part of the fuel, it is predicted that considerable economy can be effected over the use of oil.

Furnaces for burning either coal or sawdust or a mixture of the two have been designed and have met with admirable success in woodworking plants where the sawdust is a byproduct of the plant. In such plants, where additional fuel is needed only occasionally, it would seem practicable to use oil in place of coal. This kind of fuel would do away entirely with the manual handling of coal and ashes and reduce the cost of furnace construction; and at the same time provide for closer regulation of steam pressure in plants where the sawdust supply is variable than is usually possible with a coal and wood fired furnace.

Boiler furnaces for iron and steel mills are usually fired with waste gases from blast furnaces supplemented by coal fed either by stoker or hand. Why not provide such furnaces with oil burners to supplement the gas? This field would also appear to be well fitted for the use of powdered coal as an auxiliary where the plant is large.

Much has been done in developing efficient methods of using individual fuels, but there remains a great field to be explored in the scientific use of mixed fuels made up in large part from the waste materials of industries.

"No Chance to Use His Head"

Slamming down his draw bar, the fireman voiced a threat to quit; he was getting tired of the job. "It's too cut and dried here, and there's no chance to use your head or do things that get you a promotion. Wish I had something else."

Somehow the other fellow's job always seems most alluring—we rarely stop to review the possibilities of our present occupation.

This man was wrong, for the boiler room offered him a broad opportunity for frequent mental exercise. Watching the various pressure and temperature gages for correct regulation, taking an active interest in the data recorded upon the log sheet, intelligently analyzing monthly reports, keeping posted on new boiler room equipment, calling the chief's attention to studied improvements in operation, thoroughly mastering the science of combustion—all these afford an unlimited field for the use of his gray matter.

At no stage of the process of generating steam can so much be saved or wasted as in the burning of fuel. All the most perfected apparatus is useless if the fireman does not know his business and does not use his head.

THERE SEEMS to be a general impression that vocational education means a manual trade, and a good many disabled soldiers have at first rejected the idea of taking the training available to them through the Federal Board for Vocational Education on that account. Such is by no means the case, and the list of men already in training shows a considerable portion of the number to be pursuing strictly professional courses. For instance, there are 24 studying architecture; 30 taking chemistry; 21, dentistry; 68, drafting; 178, engineering; 2 are taking a course in foreign trade; 9 are studying journalism; 7 are taking languages; 61 are taking mechanical drawing; 8 are studying music; 2 are qualifying as opticians; 49 are studying law; 8 are qualifying as teachers; 4 are studying theology; 3 as veterinary surgeons; and 8 as wireless operators.

Power Factor Surveys

LOW power factor is a good deal like Bright's disease, we can have a bad case of it in our system and not know it. It takes a specialist to find it, if he gets hold of us before the undertaker does. Low

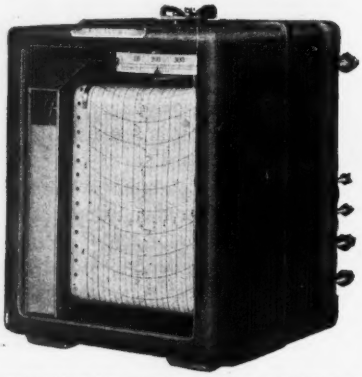


FIG. 1. SWITCHBOARD TYPE POWER FACTOR RECORDER

power factor decreases the capacity to produce and the efficiency of the system affected by it. While the cause may be only local, its evil effects usually extend throughout a system. It can largely be prevented, and where it already exists it can be cured.

Before remedial measures can be undertaken, however, it is necessary to make surveys which will show the power factor values, their variation and the location of the principal apparatus producing the conditions found. For this purpose the graphic recording power factor meter shown in Fig. 1 is claimed to be the most reliable and convenient method of obtaining the necessary information. As the power factor on a distributing feeder or in an industrial plant is not constant, it is desirable to take records over a sufficient period to insure their being representative.

In beginning a power factor survey, whether in a central station or an industrial plant, records are first taken in the generating room, a separate test being made on each outgoing line. On those lines or feeders showing low power factor, tests are then made at branches in the distributing system, until the equipment responsible for the low power factor is found.

In cases where rates are based upon the maintenance of a given power factor, it is the usual practice to install power factor recording instruments permanently or make periodic tests of a representative character.

Figure 2 shows a section of a power factor record from a survey made by a central station. It clearly indicates the power factor which would exist on one of its feeders if no corrective apparatus were employed and the excellent results obtained by the installation of a large synchronous machine in one of its customer plants.

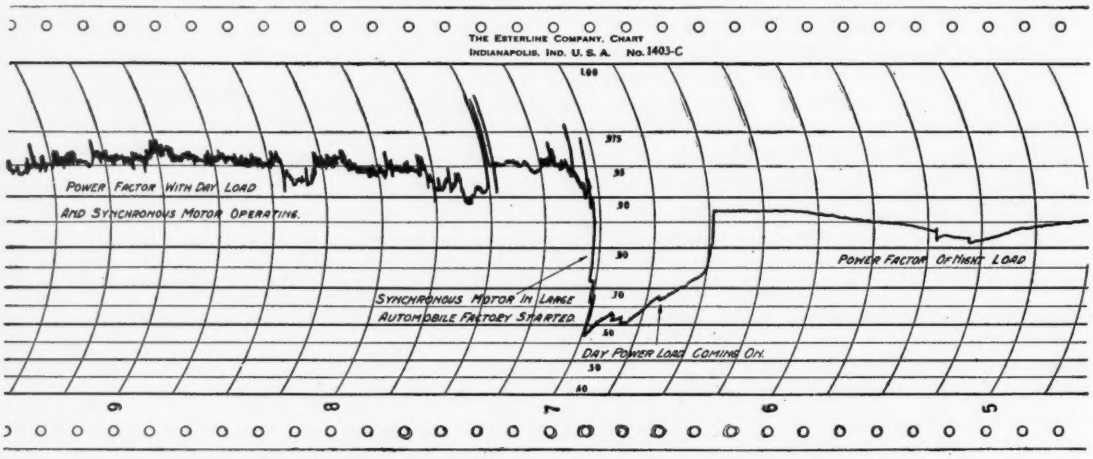
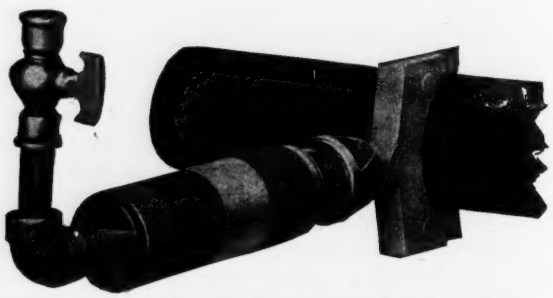

THE ESTERLINE COMPANY, CHART
INDIANAPOLIS, IND. U. S. A. No. 1403-C
POWER FACTOR WITH DAY LOAD
AND SYNCHRONOUS MOTOR OPERATING.
SYNCHRONOUS MOTOR IN LARGE
AUTOMOBILE FACTORY STARTED
DAY POWER LOAD COMING ON
POWER FACTOR OF NIGHT LOAD

FIG. 2. SECTION OF CENTRAL STATION POWER FACTOR RECORD

The Mound Rapid Pipe Cleaner

ENGINEERS and operators having charge of atmospheric ammonia and steam condensers, well know the hard and tedious labor required to remove the coating of scale bound to form on the pipe and fittings of such pieces of apparatus. As a rule, this is done by hand and requires much time, thus rendering it an exceedingly expensive process.

It is, however, possible by the use of the pipe cleaner, shown herewith, to eliminate much of this work; in fact, it is said that by the use of this cleaner it is possible for one man to accomplish more than three cleaning by hand and then do a much better and more uniform job. Essentially this useful little tool consists of a cutter holder fitted with two pivoted cutters having an inside radius



METHOD OF APPLYING THE MOUND RAPID CLEANER

of curvature equal to that of the exterior of the pipe or tube to be cleaned. It is operated by a pneumatic hammer working under an air pressure of from 50 to 60 lb.

and striking light blows in rapid succession, dislodging the scale and rust within a minimum length of time.

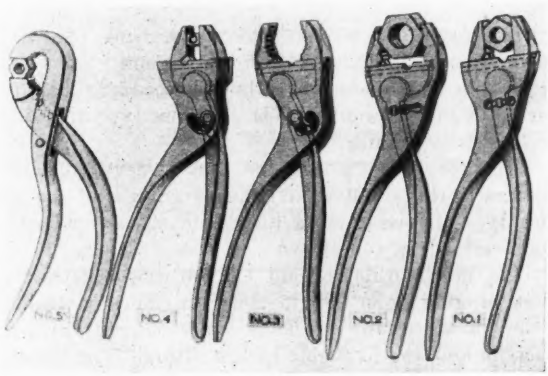
One-half of the peripheral surface of the pipe or tube, is cleaned at one operation and where drip strips are used, these may be readily cleared by a slight grinding down of the ends of the cutters.

Square Jawed Plier Wrenches

TWO new kinds of plier wrenches that will fill the long felt want in any mechanic's tool kit, are illustrated herewith. These wrenches are quick acting, self-adjusting, always taking a firm grip on any object that may be clamped in the jaws. They are made simple and of few parts.

The main features that A. C. Allan, the inventor, claims for these wrenches are: that they are self-adjusting, and that the jaws are always parallel when clamping objects of various sizes, or when the jaws are closed or wide open.

It does not matter whether the jaws are closed or wide open or clamping nuts, pipes or objects of various sizes, the grip of the handles is always the same.



NEW TYPES OF PLIER WRENCHES

Referring to No. 1 you will notice the jaws are clamping a medium size nut, while in No. 2 the jaws are clamping a large size nut and the jaws are nearly open. If you will carefully notice you will observe that the handles are in about the same position irrespective of the jaws opening. It will also be seen in No. 1 while the jaws are gripping a medium size nut the adjustment pin on the lever is in the second hole of the slot way adjustment. While in No. 2 the lever adjustment is in the end hole of the slot way. The difference between Nos. 1 and 2 and 3 and 4 is that in Nos. 1 and 2 the handle carries a solid pin while in Nos. 3 and 4 the adjustment pin is loose to adjustment in a slot way through the handle; also through the sides or walls of the wrench body.

Referring to No. 5 you will observe the jaws clamping a medium size nut; also notice the jaws are parallel while clamping nuts or any object with a square or flat surface. While this form of a plier wrench looks more like a pipe wrench, it has a hook jaw and is well adapted to clamp pipes or nuts of various sizes, and still retain the proper grip on the handles. This form of a plier wrench is absolutely self-adjusting from wide open to closed position of the jaws by simply gripping the handles.

What the inventor claims about these plier wrenches is: that the jaws are always parallel when clamping objects of various sizes. The jaws are variable not only in their degree of separation, but also in the degree of angularity of their operation relative to the handles. Another point about this plier wrench is that you can get a ratchet motion on nuts and pipes by simply releasing the handles and taking a new grip. The harder the pull on the handles the harder the grip on the jaws.

M. T. Davidson

MARSHALL TEN BROECK DAVIDSON, President of the M. T. Davidson Co., builders of Davidson pumps and pumping engines, died at his home in Brooklyn on April 10. Mr. Davidson was one of the oldest members of the American Society of Mechanical Engineers, also member of the Society of Naval Architects and Marine Engineers, the Naval Order of the United States, Associate Society U. S. Grant Post No. 327, The Columbia County Association, life member of the Navy League, and was, from its conception, an active and life member of the late Union League Club of Brooklyn.

He was born in Albany, 1837, and from his early boyhood showed great interest in steam machinery, particularly the locomotive and steam boat engines. In 1857 he entered a marine engine machine shop, foot North Moore Street, New York City, and later went to sea as assistant engineer on ocean steamers.

Upon the breaking out of the Civil War he was Assistant Engineer on a steamer running from San Francisco to the various settlements on Puget Sound. He came East in 1862 as volunteer Second Assistant Engineer in the Naval Service, but was requested to accept a position as chief engineer of an army transport, building at Wilmington, Del. He superintended the construction and installation of the machinery of this vessel, and after its completion received a commission as chief engineer in the Revenue Cutter Service, and superintended the building and installation of the machinery for that service.

At the close of the war Mr. Davidson became a contracting engineer, and in 1878 started the business which is now carried on in Brooklyn, N. Y., building pumps and pumping engines.

His knowledge of character and strong attachments to those he liked and trusted created the faithful staff whom he gradually brought to operate the business on the lines laid down by him, and in the corporation formed some years ago, to carry on his work, the same "Davidson" men, who had been with him for 25 yr. or more, were given charge of the business to carry it on the principles on which they are so well grounded.

Mr. Davidson was closely identified with the progress of engineering in the United States Navy since the building of the "White Fleet," which marked the beginning of our modern warship construction. His practical knowledge of engineering, especially as applied to pumping machinery, placed him at the head of his profession in that line, and he was identified with the work of the Mississippi and Missouri River Commissions of the United States government, large pumping engine installations in Brooklyn, N. Y., and many other cities. His

favorite study was marine work and the development of pumps as now built for use on shipboard was largely due to his inventive genius and exact knowledge of the requirements.

News Notes

THE OHIO BRASS CO., Mansfield, Ohio., announces the removal of its Chicago office from 508 Fisher building to 1217 Fisher building, 343 South Dearborn St., the telephone number having been changed to Harrison 4343.

THE TECHNICAL PRODUCTS CO., Inc., and the Hercules Engineering Corp., of 501 Fifth Ave., New York, announces the appointment of A. B. Curtis, Jr., as Western Manager, with headquarters at 728 Monadnock Bldg., Chicago.

THERMAL APPLIANCE CO. is now located in its new plant at Port Ave. and Third St., Elizabethport, N. J., Telephone, Elizabeth 4396, which has been fully equipped to make prompt shipments of products. The headquarters of the company will be at the plant.

THE TERRY STEAM TURBINE CO., Hartford, Conn., announces the appointment of R. L. Thomsen as Sales Manager. Previous to his appointment, Mr. Thomsen was manager of the Marine Department for the Griscom-Russell Co.

NELSON B. GATCH was recently appointed district manager of sales for the Chicago Pneumatic Tool Co. at Minneapolis, with offices at 301 Metropolitan Bank Building, and J. K. Haigh to a similar position with the same company at the San Francisco office, 175 First Street. The company has moved its Milwaukee office from Room 1305 Majestic Building, to Room 1418, in the same building, where more convenient quarters necessitated by the growing business of the company in this district have been obtained.

DEAN BROS., Steam Pump Works, Indianapolis, announces that in order to take care of its increased business in New York and vicinity, it has opened a sales office at 141 Broadway. H. Meachem has been appointed to furnish estimates and hydraulic engineering information in connection with the company's complete line of pumping machinery.

IN A NEWS item published on page 435 of the May 1 issue, it was stated that a number of ball bearing manufacturers had combined interests. Later information from the new company—S. K. F. Industries, Inc.—states that certain parts of the previous announcement are in error, as there will be no physical consolidation of the underlying companies but simply a holding, sales and engineering organization.

R. E. THOMPSON has been appointed manager of the Deming Ice & Electric Co., Deming, New Mexico, to succeed M. E. DeFrance, who has gone to Trinidad, Colorado, as Superintendent of Power for the Trinidad Electric Transmission Railway & Gas Co.

THE HOMESTEAD VALVE MANUFACTURING CO., of Homestead, Pa., has added Charles Nagle to its New York office. Mr. Nagle will call upon the trade within New York City and Brooklyn. It has also placed an additional man in the Pittsburgh office, in the person of F. H. Thorn, who has had several years of broad experience in the mechanical engineering field. Mr. Thorn will devote his time exclusively to the plants within the Pittsburgh district.

Trade Notes

SCOTT VALVE MFG. CO., of Detroit, which was incorporated Jan. 7, 1919, is in reality a pioneer in the valve industry, as the new corporation is merely a change of name of the Roe-Stephens Mfg. Co., which has made Scott valves for 35 yr. and which also acquired the plant and assets of Jas. Flower & Bros., who began business in 1852. This addition took place in 1893, after the Roe-Stephens Co. had been in business 9 yr., and in 1903, C. W. Thomas, president, bought the business of the Michigan Brass & Iron Works, which was merged with that of the Roe-Stephens Co. The company recently decided to concentrate its efforts on the one line of valves, and the change was made so that the company name would conform to that of the product. Mr. Thomas remains as president of the Scott Valve Mfg. Co.

THE DISTINGUISHED position which B. V. Nordberg has attained as a designer of steam engines lends special interest to the announcement by the Nordberg Manufacturing Co., of Milwaukee, Wis., of a new type of Uniflow poppet valve engine.

The Nordberg Co. was the first to develop Uniflow engines in this country, and the advantages of the Uniflow type in maintaining high economy at underloads and overloads is well known.

The new Nordberg-Todd Uniflow engine is built in sizes ranging from 200 to 2000 hp. for any available steam pressure, any available superheat, any available vacuum and any available back pressure. The assertion is made that under any of these conditions these engines will operate with lower steam consumption per horsepower, over wider variations of load, than any steam prime mover thus far developed.

Of special interest is the fact that the engine can be changed from condensing to noncondensing operation, or the reverse, while running.

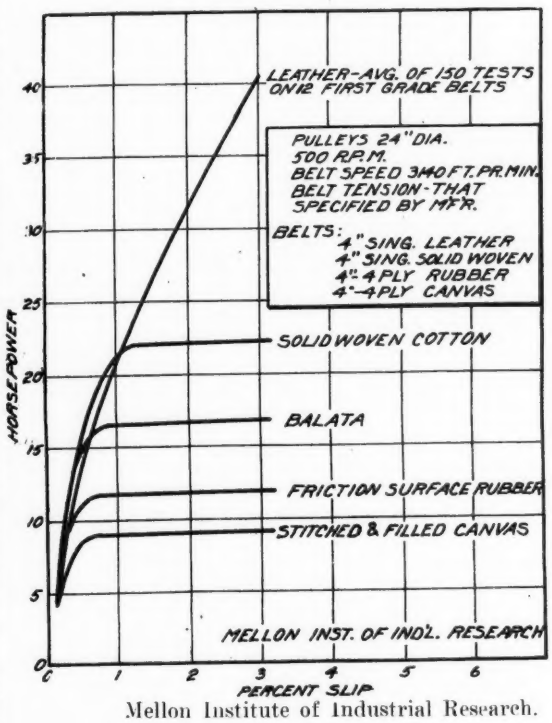
PIONEER RUBBER MILLS is the name under which the Bowers Rubber Works, of San Francisco, is now operating. The change in name became effective April 1, but the management and policy of the company continue as under the old name. The new name has been adopted as more indicative in scope and location of the Pioneer Rubber Mills, which are the largest west of Chicago and were the first established on the Pacific Coast.

The Bowers Rubber Works began business in San Francisco in 1888 and has continued to grow and expand until today it has attained an international reputation for its products. Its mills are located at Pittsburg, Contra Costa County, Calif., on the Sacramento River, a few miles from San Francisco. Pioneer Rubber Mills today maintains factory sales offices in Portland, Tacoma, Seattle, Los Angeles, Salt Lake and Denver, while it has distributors all over the United States. George N. Towne is Vice President and General Manager of the company, D. D. Tripp is the Vice President in charge of sales. The general offices are at 68 Sacramento St., San Francisco.

These tables contain data especially worked out or carefully selected that are vital to your work. You may need them at any time and should preserve them. A handy, serviceable, loose-leaf cover in which these tables fit exactly, will be sent you for 30 cents in currency or stamps.

POWER PLANT ENGINEERING

HORSEPOWER-SLIP CURVES



Mellon Institute of Industrial Research.

POWER PLANT ENGINEERING

COOLING WATER REQUIRED FOR AFTERCOOLERS, INTERCOOLERS AND AIR COMPRESSOR CYLINDER JACKETS

Compressed Air Data.

	Gallons of water per 100 cu. ft. actual free air for different water temperatures			
	60 deg.	70 deg.	80 deg.	100 deg.
Aftercooler or Intercooler separate (80-100 lb. 2-stage compression)	2.5	3.	3.5	4.
Intercooler and Jackets in series (80-100 lb. 2-stage compression)	2.9	3.4	4.0	4.5
Aftercooler for 80-100 lb. single stage compression	4.0	4.5	5.2	6.0
Both low and high pressure jackets with water supply separate from Intercooler (80-100 lb. 2-stage compression	.085	1.0	1.2	1.4
Jacket for single stage comp. 40 lb. air pressure	0.5	0.6	0.7	0.9
Jacket for single stage comp. 60 lb. air pressure	0.6	0.7	0.8	1.0
Jacket for single stage comp. 80 lb. air pressure	0.7	0.8	0.9	1.1
Jacket for single stage comp. 100 lb. air pressure	0.8	0.9	1.0	1.2

POWER PLANT ENGINEERING

BAROMETRIC READINGS, BOILING POINTS AND ALTITUDES

Barometer Reading Inches Mercury	Barometer Reading Millimeters Mercury	Boiling Point ° F.	Boiling Point ° C.	Altitude in Feet Approximate
30.52	775.2	213.0	100.6	— 550
30.40	772.2	212.8	100.4	— 450
30.28	769.1	212.6	100.3	— 340
30.16	766.1	212.4	100.2	— 230
30.04	763.0	212.2	100.1	— 120
29.92	760.0	212.0	100.0	0
29.80	756.9	211.8	99.9	100
29.68	753.9	211.6	99.8	210
29.57	751.1	211.4	99.7	310
29.45	748.0	211.2	99.6	420
29.33	745.0	211.0	99.5	530
29.21	741.9	210.8	99.3	650
29.10	739.1	210.6	99.2	750
28 98	736.1	210.4	99.1	860
28.87	733.3	210 2	99.0	970
28.75	730.3	210.0	98.9	1080
28.63	727.2	209.8	98.8	1190
28.52	724.4	209.6	98.7	1300
28.41	721.6	209.4	98.6	1400
28.29	718.6	209.2	98.5	1520
28.18	715.8	209.0	98.3	1620
28.07	713.0	208.8	98.2	1730
27.95	709.9	208.6	98.1	1850
27.84	707.1	208.4	98.0	1960
27.73	704.3	208.2	97.9	2060
27 62	701.6	208.0	97.8	2170
27.51	698.8	207.8	97.7	2280
27.39	695.7	207.6	97.6	2400
27 28	692.9	207.4	97.4	2510
27 17	690.1	207.2	97.3	2620
27 06	687.3	207.0	97.2	2730
26 96	684.8	206.8	97.1	2830
26.85	682.0	206.6	97.0	2940
26.74	679.2	206.4	96.9	3060
26.63	676.4	206.2	96.8	3170
26.52	673.6	206.0	96.7	3280
26.41	670.8	205.8	96.6	3400
26.31	668.3	205.6	96.4	3500
26.20	665.5	205.4	96.3	3610
26.09	662.7	205.2	96.2	3720
25.99	660.2	205.0	96.1	3830

POWER PLANT ENGINEERING

DIMENSIONS OF ELECTRICAL CONDUIT

	Diam.	Area		Diam.	Area
1/2	.62	.306	3	3.06	7.34
3/4	.82	.516	3-1/2	3.56	9.94
1	1.04	.848	4	4.02	12.7
1-1/4	1.38	1.49	4-1/2	4.5	15.9
1-1/2	1.61	2.03	5	5.04	19.9
2	2.06	3.32	6	6.06	28.8
2-1/2	2.46	4.75			

MAXIMUM NUMBER OF WIRES IN CONDUIT

	Size of Conduit					
B. & S.	1/2	3/4	1	1-1/4	1-1/2	2
14	4(3)	6	10	17(18)	24	40
12	3(1)	5	8	14	19	32
10	2(1)	4(3)	6	11	15	25
8	1	2	5	9	12	20
6	1	1	2	4	5	9
5	1(0)	1	2	3(4)	5	8
4	1(0)	1	1	3	4	7
3	..	1	1	2	4	6
2	..	1	1	2	3(4)	6
1	..	1	1	1	3	4
0	..	..	1	1	2	4
00	..	..	1	1	2	3
000	..	..	1	1	1	3
0000	..	..	1	1	1	2
225,000	..	..	..	1	1	2
250,000	..	..	..	1	1	2
300,000	..	..	..	1	1	1
350,000	..	..	..	1	1	1
400,000	..	..	..	1	1	1
450,000	..	..	..	..	1	1
500,000	..	..	..	..	1	1
550,000	..	..	..	..	1	1
600,000	..	..	..	..	(1)	1
650,000	..	..	..	..	..	1
700,000	..	..	..	..	..	1
750,000	..	..	..	..	..	1
800,000	..	..	..	..	..	1
850,000	..	..	..	..	..	1
900,000	..	..	..	..	..	1
950,000	..	..	..	..	..	1
1,000,000	..	..	..	..	..	1

POWER OF LEATHER BELTING AS USED IN AIR COMPRESSOR PRACTICE

Speed in Ft. Per Min.	600	1200	1800	2400	3000	3600	4200	4800	5400	6000
SINGLE										
Width of Belt				HORSEPOWER						
2 in.	2	4	6	8	10	12	14	16	18	20
3 in.	3	6	9	12	15	18	21	24	27	30
4 in.	4	8	12	16	20	24	28	32	36	40
5 in.	5	10	15	20	25	30	35	40	45	50
6 in.	6	12	18	24	30	36	42	48	54	60
8 in.	8	16	24	32	40	48	56	64	72	80
9 in.	9	18	27	36	45	54	63	72	81	90
10 in.	10	20	30	40	50	60	70	80	90	100
12 in.	12	24	36	48	60	72	84	96	108	120
14 in.	14	28	42	56	70	84	98	112	126	140
16 in.	16	32	48	64	80	96	112	128	144	160
DOUBLE										
Speed in Ft. Per Min.	400	800	1200	1600	2000	2400	2800	3200	3600	4000	5000
Width of Belt				HORSEPOWER							
4 in.	4	8	13	17	21	25	30	34	38	42	53
6 in.	6	13	19	25	32	38	45	51	57	64	80
8 in.	8	17	25	34	42	51	60	68	77	85	106
10 in.	10	21	32	42	53	64	74	85	96	106	133
12 in.	13	25	38	51	64	76	89	102	115	128	160
16 in.	17	34	51	68	85	102	119	136	153	170	213
20 in.	21	42	64	85	106	128	149	170	192	213	266
24 in.	25	51	76	102	128	153	179	205	230	256	320
30 in.	32	64	96	128	160	192	224	256	288	320	400
36 in	38	76	115	153	192	230	269	307	345	384	480
40 in	42	85	128	170	213	256	298	341	394	426	533

COMPARATIVE VALUES OF BELTING MATERIALS

	Rated H. P.	Total Lb. Effective Tension	Lb. Effective Tension Per Inch Width	Feet Per Min. to Give 1 H. P. Per Inch Width	Comparative Value Leather 100
Leather	25	270	68	490	100
Solid Woven	16	175	44	760	65
Balata	12	130	33	1020	49
Friction Surface Rubber	10	110	28	1200	41
Stitched Canvas	8	86	22	1500	32

Note: The above figures are safe for the various belts for continuous operation on easy drives; i.e. 180 deg. arc of contact, large pulleys, tight side on the bottom and steady load.
This refers to the heavy fabric belts, impregnated with gums and oils, and not to the lighter White Cotton Belts.

Mellon Institute of Industrial Research.

MAXIMUM NUMBER OF WIRES IN CONDUIT

B. & S.	Size of Conduit 2-1/2	3	3-1/2	4	4-1/2	5	6
14	57(74)	88(90)	118	151	190	237	342
12	46	72	97	123	155	193	280
10	36	55	75	96	120	150	216
8	29	45	61	78	98	123	177
6	15	21	28	36	45	56	81
5	11	18	24	31	39	49	71
4	10	16	21	27	34	43	62
3	9	14	19	24	31	38	56
2	8	13	17	22	28	35	50
1	6	10	13	17	21	27	39
0	5	8	11	15	19	23	34
00	5	7	10	13	16	20	29
000	4	6	8	11	14	17	25
0000	3(4)	5	7	9	12	15	21
225,000	3	5	6	8	10	13	19
250,000	3	4	6	8	10	12	18
300,000	2(3)	4	5	6	8	10	15
350,000	1	3	4	6	7	9	13
400,000	1	3	4	5	7	8	12
450,000	1	3	4	5	6	8	11
500,000	1	3	4	4	5	7	10
550,000	1	2	3	4	5	6	9
600,000	1	1(2)	3	4	5	6	9
650,000	1	1	3	4	4	5	8
700,000	1	1	3	3	4	5	8
750,000	1	1	3	3	4	5	7
800,000	1	1	2	3	4	5	7
850,000	1	1	2	3	4	4	6
900,000	1	1	2	3	4	4	6
950,000	1	1	1	3	3	4	6
1,000,000	1	1	1	3	3	4	6
1,100,000	1	1	1	2	3	3	5
1,200,000	1	1	1	1	3	3	5
1,250,000	1	1	1	1	3	3	4
1,300,000	1	1	1	1	2	3	4
1,400,000	1	1	1	1	2	3	4
1,500,000	1	1	1	1	2	3	4
1,600,000	1	1	1	1	1	3	4
1,700,000	..	1	1	1	1	3	4
1,750,000	..	1	1	1	1	2(3)	4
1,800,000	..	1	1	1	1	2	4
1,900,000	..	1	1	1	1	2	3
2,000,000	..	1	1	1	1	2	3

Note. - There are several instances in which the above table conflicts with the code. Where such conflicts occur the code allowances are designated by the figures in parenthesis.

Western Assoc. of Elect. Inspectors.

BAROMETRIC READINGS, BOILING POINTS AND ALTITUDES

Barometer Reading Inches Mercury	Barometer Reading Millimeters Mercury	Boiling Point °F.	Boiling Point °C.	Altitude in Feet Approximate
25.88	657.4	204.8	96.0	3950
25.78	654.8	204.6	95.9	4050
25.67	652.0	204.4	95.8	4170
25.57	649.5	204.2	95.7	4270
25.46	646.7	204.0	95.6	4390
25.36	644.2	203.8	95.4	4500
25.26	641.6	203.6	95.3	4610
25.15	638.8	203.4	95.2	4730
25.05	636.3	203.2	95.1	4830
24.95	633.7	203.0	95 0	4950
24.85	631.2	202.8	94.9	5060
24.74	628.4	202.6	94.8	5180
24.64	625.9	202.4	94.7	5290
24.54	623.3	202.2	94.6	5400
24.44	620.8	202.0	94.4	5510
24.34	618.2	201.8	94.3	5630
24.24	615.7	201.6	94.2	5730
24.14	613.2	201.4	94.1	5850
24.04	610.6	201.2	94.0	5960
23.94	608.1	201.0	93.9	6070
23.84	605.5	200.8	93.8	6190
23.75	603.3	200.6	93.7	6290
23.65	600.7	200.4	93.6	6410
23.55	598.2	200.2	93.5	6530
23.45	595.6	200.0	93.4	6650
23.00	584.2	199.1	92.8	7170
22.50	571.5	198.0	92.2	7770
22.00	558.8	196.9	91.6	8390
21.50	546.1	195.8	91.0	9010
21.00	533.4	194.7	90.4	9660
20.50	520.7	193.6	89.8	10320
20.00	508.0	192.4	89.1	10990
19.50	495.3	191.2	88.4	11680
19.00	482.6	190.0	87.8	12390
18.50	469.9	188.8	87.1	13120
18.00	457.2	187.5	86.4	13870
17.50	444.5	186.2	85.7	14630
17.00	431.8	184.8	84.9	15430

Calculated from Smithsonian Meteorological Tables, 3d Revised Edition.

Texas Mineral Oil Tables